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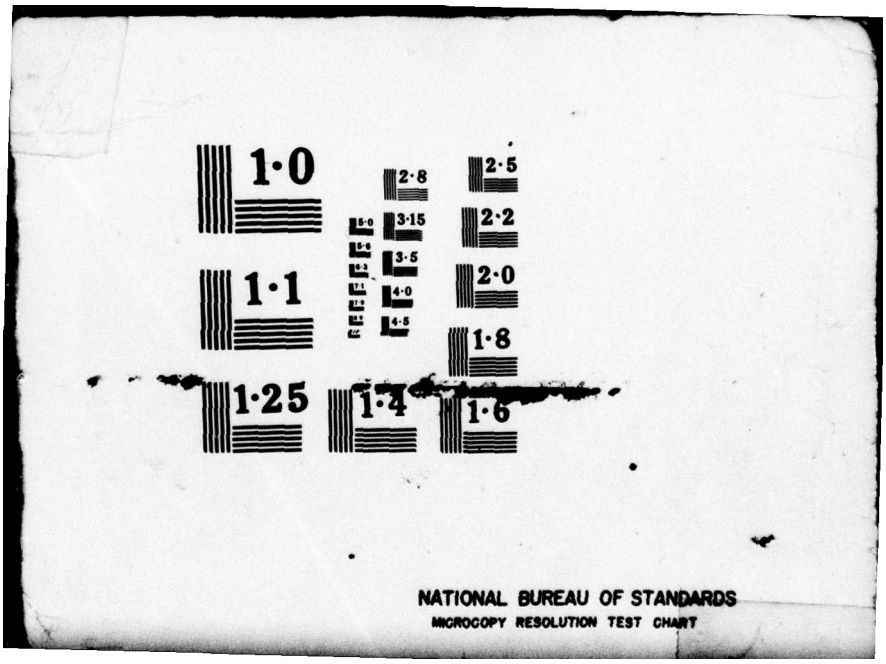
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HACKENSACK RIVER BASIN
HACKENSACK RIVER, BERGEN COUNTY
NEW JERSEY

LEVEL II

LAKE TAPPAN DAM

NJ 00246

AD A069220

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

(6) Lake Tappan Dam (NJ 00246). Hackensack River Basin, Hackensack River, Bergen County, New Jersey. Phase 1 Inspection Report.

(9) Final rept.,

(10) Robert J. Jenny

(15) DACW61-78-C-0124

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Embankments
Seepage
Concrete deterioration
Structural Analysis
Safety
Visual Inspection
National Dam Inspection Act Report
Lake Tappan Dam, N.J.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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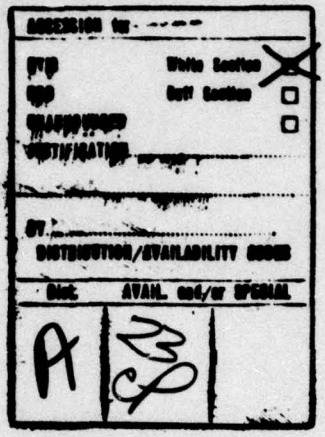

15 MAY 1979

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Lake Tappan Dam in Bergen County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Lake Tappan Dam, a high hazard potential structure, is judged to be in good overall condition and the spillway is considered adequate. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. Within six months from the date of approval of this report, engineering studies and analyses should be performed to determine the dam's embankment condition and structural stability. This should include test borings to determine material properties relative to stability and seepage. Any remedial measures found necessary should be initiated within calendar year 1980.

b. Within six months from the date of approval of this report, the following actions should be taken:

(1) The toe of the right embankment should be excavated in the vicinity of the toe drain exit to confirm if it is the source of the seepage noted in this area. If so, the soil presently covering the drain exit should be removed or replaced with free draining material. If not, steps should be taken to determine the source of seepage and to effect corrective measures.

(2) Cracks in the concrete section should be inspected and repaired as necessary to prevent concrete deterioration and excessive leakage into the inspection gallery. Measures should be taken to drain the inspection gallery and keep it drained.

(3) The piezometer located on the upper section of the left embankment should be repaired as soon as possible. The four piezometers should be read regularly to detect any irregularities in internal drainage and need for corrective action.

c. A warning system should be established whereby downstream inhabitants may be quickly notified and evacuated in the event of possible dam failure.

d. A program of annual inspection of the dam should be initiated by the owners, utilizing the standard visual check list in this report.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Harold Hollenbeck of the Ninth District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

NAPEN-D
Honorable Brendan T. Byrne

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N. J. Dept. of Environmental Protection
P. O. Box CN029
Trenton, NJ 08625

John O'Dowd, Acting Chief
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LAKE TAPPAN DAM (NJ00246)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 30 November 1978 and 4 January 1979 by Jenny-Leedshill Engineers under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Lake Tappan Dam, a high hazard potential structure, is judged to be in good overall condition and the spillway is considered adequate. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. Within six months from the date of approval of this report, engineering studies and analyses should be performed to determine the dam's embankment condition and structural stability. This should include test borings to determine material properties relative to stability and seepage. Any remedial measures found necessary should be initiated within calendar year 1980.

b. Within six months from the date of approval of this report, the following actions should be taken:

(1) The toe of the right embankment should be excavated in the vicinity of the toe drain exit to confirm if it is the source of the seepage noted in this area. If so, the soil presently covering the drain exit should be removed or replaced with free draining material. If not, steps should be taken to determine the source of seepage and to effect corrective measures.

(2) Cracks in the concrete section should be inspected and repaired as necessary to prevent concrete deterioration and excessive leakage into the inspection gallery. Measures should be taken to drain the inspection gallery and keep it drained.

(3) The piezometer located on the upper section of the left embankment should be repaired as soon as possible. The four piezometers should be read regularly to detect any irregularities in internal drainage and need for corrective action.

c. A warning system should be established whereby downstream inhabitants may be quickly notified and evacuated in the event of possible dam failure.

d. A program of annual inspection of the dam should be initiated by the owners, utilizing the standard visual check list in this report.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 11 May 1979

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Lake Tappan Dam Federal I.D. No. NJ 00246 New Jersey I.D. No. 23-91
State Located:	New Jersey
County Located:	Bergen
Stream:	Hackensack River
Dates of Inspection:	November 30, 1978 and January 4, 1979

Brief Assessment of General Condition of Dam

Based on visual inspection, Lake Tappan Dam appears to be in good overall condition.

The spillway is adequate and can pass the Probable Maximum Flood. The hydrologic and hydraulic effects of the road embankment and bridge opening immediately upstream of the dam have, at the instruction of the Corps of Engineers, been ignored for this Phase I report. However, this bridge obstruction would have an attenuating effect on the flood arriving at the dam and, therefore, tend to reduce the downstream flood magnitude.

The available analyses and engineering data indicate that the stability of the concrete gravity section of the dam is adequate; however, the available data are not sufficient to analyze the seepage and structural stability of the embankments.

Recommendations and the urgency of their implementation are as follows:

1) The toe of the right embankment should be excavated in the vicinity of the toe drain exit to confirm if it is

the source of the seepage noted in this area as soon as possible. If so, the soil presently covering the drain exist should be removed or replaced with free draining material. If not, steps should be taken to determine the source of seepage and to effect corrective measures.

2. Cracks in concrete section should be inspected regularly and should be repaired as necessary to prevent concrete deterioration and excessive leakage into the inspection gallery. Measures should be taken to drain the inspection gallery and keep it drained.

3. A program of annual inspections of the dam should be initiated in the near future.

4. The piezometer located on the upper section of the left embankment should be repaired as soon as possible. The four piezometers should be read regularly to detect any irregularities in internal drainage and need for corrective action.

5. An effective warning system to alert downstream inhabitants in case of dam failure should be implemented in the near future.

Frank L. Panuzio

Frank L. Panuzio, P.E.
Project Engineer

Robert J. Jenny, P.E.
Project Director
New Jersey License No. 9878

LAKE TAPPAN DAM

View of dam from left (south) abutment looking downstream (Nov. 30, 1978)

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

LAKE TAPPAN DAM
Federal I.D. No. NJ 00246
New Jersey I.D. No. 23-91

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The National Dam Inspection Act, Public Law 92-367, 1972, provides for the National Inventory and Inspection Program by the U. S. Army Corps of Engineers. This report has been prepared in accordance with this authority, through contract between the State of New Jersey and Jenny-Leedshill Engineers. The State of New Jersey has also entered into an agreement with the U. S. Army Engineer District, Philadelphia, to have this work performed.

b. Purpose of Inspection

The purpose of this inspection was to evaluate the general structural integrity and hydraulic adequacy of the dam, and to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project

a. Description of Dam and Appurtenances

Lake Tappan Dam, also referred to as New Jersey Dam No. 3, is a combination concrete gravity overflow and earthfill structure with a total length of 590 feet (Plates 2 and 3.)

The central concrete spillway section is approximately 245 feet long and 34 feet high, and has four 50-foot long by 6-foot high automatic bascule gates. The gates are separated by 8.25 foot wide concrete piers which support a bridge deck across the spillway section of the dam. An inspection gallery 7 feet high and 10 feet wide extends along the base of the concrete section of the dam. A concrete apron with concrete baffle blocks in the upstream half and with an end sill and sheet pile cutoff extends 71 feet downstream from the spillway. The downstream channel is lined with a four feet thick layer of dumped riprap on 2 feet of bedding stone and extending approximately 50 feet downstream from the apron.

Rolled earthfill embankments, with maximum heights of 34 feet and a combined length of 345 feet, are located on each side of the concrete dam section. These embankments were specified to be homogeneous, rolled fill consisting of clayey material. (Plate 4) The upstream faces are covered with 2 feet of riprap from the intersection with the original ground to 4 foot below the top of the dam.

A clay blanket, approximately 2 feet thick, covers the upstream channel and original banks, extending 146 feet upstream of the dam center line.

A steel sheet pile cutoff wall extends down 56 feet below the dam crest, in a line about 19 feet upstream of the dam axis.

A 4 feet by 4.5 feet outlet conduit passes through the right side of the concrete section of the dam and exits on the downstream side of the spillway. The cast iron sliding outlet gate can be controlled manually or mechanically from the crest of the dam. (Plate 8)

A control room which houses the electric control panels, oil pressure tank, oil sump and pumps and air compressor, is located on the right embankment, 15 feet from the spillway.

b. Location

Lake Tappan Dam is located in northeastern New Jersey in Bergen County approximately 1 mile south of the New York border. The dam is situated on the Hackensack River 1/2 mile north of the Borough of Old Tappan. The regional vicinity map is presented on Plate 1.

c. Size Classification

The storage capacity of Lake Tappan is 19,400 acre-feet when the reservoir surface is at the dam crest; therefore, the size classification of the dam is Intermediate, even though the dam's size classification is 'small' based on its height of 34 feet.

The criteria for size classification of dams are set forth in the Corps' Guidelines. An intermediate size dam is one in which the reservoir capacity is greater than or equal to 1000 acre-feet and less than 50,000 acre feet, and/or the maximum height is greater than or equal to 40 feet and less than 100 feet.

d. Hazard Classification

Although no structures were visible immediately downstream from the dam, the Boroughs of Old Tappan (population 4000) and Rivervale and medium duty roads are located approximately 1/2 to 3/4 miles downstream. Routing of the Probable Maximum Flood indicates that two roads and approximately 15 houses would be inundated. Due to this potential hazard to loss of more than a few lives and extensive property damage in the downstream area the dam has a high hazard classification in accordance with the Corps' Guidelines.

e. Ownership

The dam is owned by the Hackensack Water Company, 4100 Park Avenue, Weehawken, New Jersey, 07087.

f. Purpose of Dam

The reservoir is used primarily for water supply and secondarily for recreation.

c. Elevation (ft. above MSL)

. Top dam	64
. Maximum pool-design surcharge (SDF)	58.1
. Spillway crest (gated)	55
. Streambed at centerline of dam	32
. Maximum tailwater	50 (approx.)

d. Reservoir Length (mi.)

. Maximum pool (SDF)	6.3
. Operational pool	5.1

e. Storage (acre-feet)

. Normal pool (elev. 55)	10,650
. Design surcharge (elev. 58.1)(SDF)	13,600
. Top of dam (elev. 64)	19,400

f. Reservoir Surface (acres)

. Top dam	1,270
. Spillway crest	560

g. Dam

. Type	Overflow gravity and earthfill structure	
. Length		590 ft.
. Height		34 ft.
. Top width		12 ft.
. Side slopes (embankments)		
- upstream		2.5 H:1V
- downstream		2.5 H:1V
. Cutoff	Steel sheet piling	

g. Design and Construction History

The dam was designed by Buck, Seifert and Jost, Consulting Engineers and John S. Cotton, Consulting Engineer in 1964. The bascule gates were furnished by the Allis-Chalmers Manufacturing Company. The dam was constructed in 1965 and 1966. The specifications indicate that monthly reports of the dam's construction were to be submitted to the engineers, however, these records are not presently available.

h. Normal Operational Procedures

The reservoir reportedly normally fills in the fall and spring. The reservoir level is controlled automatically by 4 bascule gates so operated as to maintain a maximum reservoir stage of elevation 55 feet. A minimum flow of 3 million gallons per day is required downstream to maintain adequate flow for fish and a minimum staff gage reading of 1.5 feet at Rivervale. Water is released through the outlet works when the reservoir level is below elevation 49 feet.

An emergency generator is available to operate the electrical equipment should a power stopage occur.

The owner's personnel inspect the dam every other hour around the clock and every hour during heavy rains. Any noted debris is removed during these regular inspections.

1.3 Pertinent Data

a. Drainage Area	49.4 sq. mi.
b. Discharge at Damsite	
. Maximum known flood at damsite	3500 cfs Sept. 12, 1971
. Gated spillway capacity at pool elevation (elev. 55)	10,000 cfs
. Total spillway capacity at design maximum pool elevation (elev. 58.1)	19,770 cfs
. Total spillway capacity at top of dam (elev. 64)	45,000 cfs

h. Spillway

. Type	Free overfall
. Length of weir	245.25 ft.
. Crest elevation (ungated)	49 ft.
. Gates	Four bascule gates, 6 ft. high by 50 ft. long
U/S Channel	Approach channel d/s of roadway embankment and bridge. (53' x 22' opening)
D/S Channel	Concrete apron with baffle blocks and rip-rap blanket further downstream

i. Regulating Outlets — 4 ft. by 4.5 ft. cast iron sluice gate

SECTION 2: ENGINEERING DATA

2.1 Design

a. Geologic Conditions

Lake Tappan Dam is located in the northern portion of the New Jersey Piedmont Lowlands physiographic province. The regional geology of this province is discussed in detail in Appendix C to this report.

Geologically, the dam is situated on a broad rolling glacial till plain at a point where the river cuts through a ridge of glacially derived sediments. The ridge is a recessional moraine which formed as the Wisconsin Age continental glacier paused during its retreat northward. The reservoir occupies a swamp area which was at one time a small lake formed between the face of the glacier and the recessional moraine. Evidently, the lake rose between the glacier and the moraine until it overtopped the moraine and the outlet stream eroded through into the moraine. This method of formation would explain the relatively narrow outlet which the dam occupies in front of the broad expanse of the reservoir.

The soil of recessional moraines is typically composed of a non-residual, usually unstratified heterogeneous mixture of soil fractions ranging in size from clay to boulders with sand-sized grains in predominance. Lenses and pockets of silt are typically common and local stratification is not unusual.

Borings drilled by the Hackensack Water Company (Plate 5) in 1964 as part of the exploration program for the dam confirm the extreme heteogeneity of the soil materials underlying

the dam. The soils change rapidly both vertically and horizontally, over short distances. The predominance of the permeable sand size fraction within the soils is reflected by the relatively constant groundwater elevation which varies by only 6 feet in 700 lateral feet while the ground surface changes by 50 feet over the same distance.

Bedrock is approximately 60 feet below the center of the valley at an elevation of -20 M.S.L. and drops off to more than -30 feet toward the right abutment. Bedrock in the area is the Brunswick formation, a soft red shale with interbedded sandstones.

Material for the embankment section of the dam was obtained wholly from the reservoir area. Through the efforts of the Hackensack Water Company Engineering Department personnel, the contractor who constructed the dam was present during the inspection. He stated that all required embankment materials were excavated by use of selective borrow areas in the reservoir.

Since the area lies within Seismic Zone 1, only minor damage may be expected from distant earthquakes. No active faults are known to exist in the immediate vicinity nor surrounding area of the dam.

b. Design Data

Lake Tappan Dam was designed by Buck, Seifert and Jost, Consulting Engineers and John S. Cotton, Consulting Engineer, in 1964. Plans, typical sections, details and logs of the exploration borings are presented on as-built drawings, dated October, 1964. The design of the electrical facilities are shown on as-built drawings, dated March, 1966. Copies of selected drawings are included as Plates 2 through 9 of this report.

Discharge over the spillway is designed to be controlled by four bascule gates measuring 6 feet high by 50 feet long. These gates are supported in bays along the crest of the spillway between the piers (Plate 7). The gates are raised and lowered by automatic, hydraulic piston-operated mechanisms located in the piers. The operation of each gate is individually and automatically controlled by a float-actuated control valve which in turn is actuated by the elevation of water in the reservoir. The controls are arranged to lower the gates in six-inch increments for lake levels rising above elevation 55.5 feet. The gates return to the fully raised position when the lake level drops to elevation 55.0. Manual operation also is provided.

The spillway was designed for a maximum probable flood of 35,000 cfs. The spillway discharge curve (Plate 5) based on model tests, indicates that this flood corresponds to a reservoir water surface elevation of 62 feet.

Overturing, sliding and foundation bearing pressure analyses for the concrete section of the dam are also available.

Invitation and instructions to bidders, specifications, proposal and contract and bond documents, dated February, 1965, were also prepared by the design engineers.

The specifications for construction of the dam indicate that the material for the earthfill embankments and clay blanket for the upstream bank and apron was to be 'clayey glacial till soil' obtained from borrow areas in the reservoir area. (Plate 1). The earthfill embankments were to be placed in layers and compacted to a minimum of 100% of the maximum dry density determined by the ASTM Standard Density Test, D-698-58T, using sheepsfoot or heavy pneumatic-tired rollers. Compaction of the earthfill within 5 feet of the training walls

and cutoff walls was to be done using hand mechanical tampers. Specifications for the mixing and placement of the concrete were also given.

2.2 Construction

The specifications indicate that an inspector appointed by the design engineers was to be at the site during construction and monthly reports describing the construction progress were to be prepared by the contractor and submitted to the engineers. However, neither these reports nor other data regarding the construction of the dam are presently available.

2.3 Operations

The reservoir level is controlled automatically by four bascule gates set to maintain a maximum reservoir stage of elevation 55 feet. These gates are reportedly operated manually twice a year. A flow of 3 million gallons per day must be released by the dam to maintain minimum State requirements for downstream fish.

The owners check the dam every two hours, except during storms at which time the dam is observed every hour.

Four piezometers were installed in the embankments shortly before these inspections. Reading from the piezometers have not been obtained; however, monthly readings were scheduled to begin soon after the inspections.

An infrared cross beam is used to detect trespassers at the dam. In addition, an alarm system is attached to the gate control vaults and activated by ionized detectors.

2.4 Evaluation

a. Availability

Available engineering data for the dam consist of as-built drawings, construction specifications, stability analyses and hydrographs for storms occuring between 1971 and 1975. Most available data are listed in Appendix A.

b. Adequacy

The available design and construction data are adequate to check the stability analysis of the concrete gravity section of the dam. Available data are insufficient to verify the foundation bearing pressures and sliding coefficients presented on Plate 4; however, these values appear reasonable. Due to the absence of construction data and material properties the structural stability and seepage through the earthfill embankments cannot be accurated evaluated.

c. Validity

Visual inspection of the dam indicated that the dam was constructed generally as shown on the available drawings. The stability analysis of the concrete gravity section of the dam shows this section to be adequately designed against overturning and sliding. Review of this analysis indicates that accepted methods of calculation were used.

The embankment sections of the dam appear to be adequately designed; however, stability and seepage analyses are recommended as discussed in Section 7.1-d.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

Visual inspections of Lake Tappan Dam were made on November 30, 1978 and January 4, 1979. During the earlier inspection the reservoir level was at elevation 44.8 feet and water was being released through the outlet works at the rate of approximately 22 million gallons per day.

The visual inspection did not reveal any critical signs of distress in the dam. There was evidence of cracking and leakage in the gallery. In addition, cracking of the training walls and some spalling of the piers where they connect to the bridge deck were also observed.

Detailed inspection was made of the dam, appurtenant structures, reservoir area, and the downstream channel. Descriptions of the findings of these inspections are summarized in the paragraphs which follow. The checklist of visual inspection items is included in Appendix A. Geologic and foundation conditions observed at the time of inspection are noted in greater detail in Section 2.1-a.

b. Dam

The dam was inspected for signs of settlement, seepage, erosion, cracking, and any other evidence of undesirable behavior which might affect the stability of the structure.

Concrete Gravity Overflow Structure

The central portion of the dam consists of the spillway, which is a concrete overflow gravity structure. This

concrete section of the dam is divided into four bays by five concrete piers which support a 12-foot wide deck across the length of the spillway (Photos 1 and 2). The piers and bays are numbered consecutively from the right (north) to the left. There were no signs of distortion of the vertical or horizontal alignment of this section of the dam.

Cracks, extending perpendicular to the axis of the dam, were observed at each bay, spaced approximately one-third of the bay span from the piers (Photo 2). These cracks coincide with those observed inside the gallery which passes through the center of the concrete section of the dam. Seepage has occured through the cracks and construction joints as evidenced by minor seepage and lime deposits along the cracks inside the gallery. There was about 2 inches of water on the floor of the gallery during the inspection. Due to the relatively low reservoir level and general dampness of the inside surface of the gallery, it could not be determined whether the cracks are the only source of this standing water.

Several vertical and diagonal cracks with minor leaching were observed on the left retaining wall downstream of the spillway (Photo 3). Minor cracking was also noted at 6- to 10-foot intervals on the sill at the downstream edge of the concrete spillway apron. In addition, minor vertical cracks were observed in the right abutment retaining wall. These cracks do not appear to have any structural significance.

Weep hole drains are present at the downstream sides of the training walls. No seepage was noted during the inspection.

No vertical or horizontal offset or misalignment of the gate bay deck was observed (Photo 4).

Contact between the concrete structure and embankment appears to be good, with no visible offset or separation.

Embankments

The downstream face of each embankment is covered with grass and small evergreen trees have been planted along the upstream edge of the crest (Photo 5 and Overview Photo). A dirt service road extends along the top of both embankments and joins the concrete bridge decking. The upstream faces of the embankments are covered with riprap which also extends approximately 125 feet upstream from the dam along the north bank of the approach channel. The south bank of the approach channel from the dam is covered with a clay blanket (Photo 6).

Two piezometers, one 15 feet above the toe of the embankment and one 17 feet below the crest, are located on each embankment section. (See arrow on Photo 5). The top of the upper piezometer on the left embankment (Plate 9, Piezometer No. P-1) has been broken off at the ground surface.

A minor seep flowing clear at a rate of less than 1 gallon per minute was observed approximately 10 feet downstream of the right embankment adjacent to the training wall (Photo 7). This seepage is possibly the result of recent rains exiting at the embankment toe drain outlet (Plate 9).

c. Appurtenant Structures

Bascule Gates

Six-foot by 50-foot bascule gates are located in each of the four spillway bays. (Photos 1 and 8). The gates

appear to be in excellent condition and well maintained; however, the water tightness of the seals could not be determined because the reservoir stage was below the level of the gates. Flow splitters have been installed at the top of the gates to change the harmonics of the flow so as to reduce downstream disturbance. The hoisting equipment is located in the piers and also appear to be in very good contition. (Photo 9). Mechanical stops have been installed on the gate operating cylinders to ensure that jamming of the gates would not occur during a flood. Gate No. 1 was successfully operated during the inspection.

Outlet Works

The outlet works were submerged at the time of the inspection and, therefore, could not be inspected. The control valve, located at the upstream side of the right end of the spillway deck, is well maintained.

Water was flowing through the sluice at a reported rate of 22 mgd during the inspection. A section of the sill on the downstream edge of the concrete apron adjacent to the right abutment has been removed to facilitate the discharge from the sluice (Photo 10).

d. Reservoir Area

A road embankment and bridge are 300 feet upstream of the dam, and a trestle supported 24-inch diameter gas main (elev. 60) is 50 feet downstream of the roadway. Flow from the reservoir passes through a 53-foot wide by 22-foot high bridge beneath the center of the road embankment. (Photo 11).

The slopes surrounding the reservoir are gently sloping and appear stable.

The water in the reservoir was clear and there was no apparent evidence of sedimentation. Two staff gages are attached to the upstream end of the right training wall (Photo 6).

e. Downstream Channel

The downstream channel is a steeply graded streambed within a somewhat wider flood channel, well defined, but relatively shallow having a wide base trapezoidal cross-section. Much of the downstream flood plain is swamp and heavily wooded. The slopes are gentle and the debris potential is high. No building or roads were visible downstream from the dam.

SECTION 4: OPERATIONAL PROCEDURE

4.1 Procedures

Normal operation of the dam is to maintain a reservoir level of elevation 55 feet to provide a regulated flow of water downstream. A minimum discharge of 3 million gallons per day is required. The reservoir level is maintained by four bascule gates which are automatically controlled by a float control valve which is actuated by the elevation of water in the reservoir. The controls are set to lower the gates in 6-inch increments for reservoir levels rising above elevation 55.5 feet. The gates return to the fully raised position when the reservoir level drops to elevation 55.0 feet. The gates can also be operated manually.

Water is released through the 4.5 by 4 feet outlet conduit when the reservoir level drops below elevation 49 feet so as to maintain minimum flow requirements. Discharge through the o outlet is controlled by a cast iron sluice gate which can be operated by a motor or manually.

The dam is checked every two hours by the owner's personnel, except during heavy rains, at which time the dam is observed hourly. The reservoir elevation and degree set of the bascule gates are recorded during storms.

Four piezometers were installed in the embankments shortly before the inspections. Measurements are scheduled to be taken every month, beginning soon after the inspections.

4.2 Maintenance of Dam

The dam is maintained primarily by the owner, Hackensack Water Company. The maintenance crews are responsible for maintenance of the dam, removal of debris from the reservoir and gates and the regular observation of the dam.

The maintenance of the upstream face of the embankments is reportedly performed by the towns of Rivervale and Old Tappan.

4.3 Maintenance of Operating Facilities

The bascule gates and outlet works are maintained by the Hackensack Water Company. The bascule gates are reportedly operated manually twice a year.

4.4 Description of Warning System

There is no formal warning system to alert downstream inhabitants of floods or possible failure of the dam. However, the dam is patrolled regularly, as described above, and the local police will reportedly contact the owners should problems arise.

Infrared cross beam rays are used to detect trespassers at the dam. In addition, an alarm system is attached to the gate control vaults. Each mechanical system is operated separately thus, reducing the possibility of total damage of the system.

4.5 Evaluation of Operational Adequacy

The operational procedures appear to be well planned and maintenance of the dam is exceptionally good. However, the implementation of a planned warning system to alert downstream inhabitants in time of floods and misoperation of the dam is recommended.

SECTION 5: HYDRAULICS/HYDROLOGY

5.1 Evaluation of Features

a. Design Data

As already stated in Section 1.2, Lake Tappan Dam is classified as high hazard and intermediate in size. In accordance with the Corps of Engineers' "Recommended Guidelines for Safety Inspection of Dams " the Spillway Design Flood (SDF) is the Probable Maximum Flood (PMF).

Data obtained from the owner indicate the drainage basin area of Lake Tappan Dam is 49.4 square miles. This drainage basin was divided into two sub-basins - the upstream basin above DeForest Lake Dam that has a drainage area of 26.6 square miles, and the intermediate basin between Deforest Lake Dam and Lake Tappan that has a drainage area of 22.8 square miles. The sub-basin upstream of DeForest Lake Dam has already been analyzed by the Corps of Engineers, New York District, and, as requested by the Corps, the results of that analysis were used in this analysis of Lake Tappan Dam. Within the sub-basin between DeForest and Lake Tappan Dam, elevations range from a maximum of about 500 feet above sea level along the perimeter, to a minimum of about 50 feet in the valley floor. Land use patterns consist of forests and significant areas of residential development. Lake Tappan represents about 4 percent of the sub-basin area. The drainage sub-basins are delineated on a U.S.G.S. topographic map and presented on Plate D-1, Appendix D.

The hydraulic and hydrologic features of the dam were evaluated using criteria set forth in the Corps of Engineers' "Recommended Guidelines for Safety Inspection of Dams", and additional guidance and criteria provided by the Philadelphia District, Corps of Engineers. The Probable Maximum Precipitation (PMP) for the sub-basin between DeForest Lake and Lake Tappan was calculated using Hydrometeorological Report No. 33 and the Hop Brook

reduction factor for misalignment of the storm.

The PMF for the sub-basin between DeForest Dam and Lake Tappan was calculated using the Corps' computer program HEC-1, Dam Break Version. In computing the PMF the Corps recommended that the Clark Unit Hydrograph be used. The computer program developed the Unit Hydrograph using a time of concentration of 5.0 hours and the Clark storage coefficient of 9.2 hours calculated from equations supplied by the Corps.

An initial infiltration loss of 1.0 inch and a final infiltration loss rate of 0.10 inch per hour were used in the HEC-1 program to give excess rainfall. Using the excess rainfall and the unit hydrograph, the program computed the peak inflow discharges from the sub-basin of the 25 percent, 50 percent, 75 percent and 100 percent PMF. These discharges are approximately, 5,190 cfs, 10,370 cfs, 15,560 cfs and 20,740 cfs, respectively.

As previously stated, the PMF outflow hydrograph from DeForest Lake was supplied by the Corps. The peak outflows from DeForest Lake Dam for the 25 percent, 50 percent, 75 percent and 100 percent are 3,900 cfs, 7,810 cfs, 11,710 cfs, and 15,610 cfs, respectively. These outflow hydrographs were routed downstream through two successive reaches to Lake Tappan and then combined with the runoff hydrograph from the intervening sub-basin. The combined inflow hydrograph into Lake Tappan for the 25 percent, 50 percent, 75 percent and 100 percent are approximately 5,530 cfs, 11,110 cfs, 16,700 cfs and 22,340 cfs, respectively.

The various percentages of the PMF inflow hydrograph were routed through the reservoir using the Modified Puls Method by the HEC-1 program. The peak outflow discharges of the 25 percent, 50 percent, 75 percent, and 100 percent

were calculated to be approximately 4,170 cfs, 9,110 cfs, 14,370 cfs and 19,770 cfs, respectively. A plot of percent PMF versus peak outflow discharge is presented as Plate D-2 in Appendix D.

The stage-storage and spillway stage-discharge rating curves used in the flood routings were obtained from as-built drawings supplied by the dam owner. The stage-storage curve was extended to the dam crest to account for surcharge storage during peak flood flows. The spillway stage-discharge curve supplied by the owner is for the gates in a fully open position. Assuming the gates are open during the PMF, which would be the normal case due to the automatic gate system, the spillway can pass the PMF peak discharge with the maximum reservoir stage 5.9 feet below the dam crest.

In the reservoir routing computations possible discharges through the outlet works were excluded because their capacity is small compared to the PMF and because of the possibility that the outlet gates may be closed. The stage-storage and the spillway stage-discharge curves are presented in Appendix D as Plates D-3 and D-4, respectively.

The various percentages of the PMF were routed 1.9 miles downstream through three successive reaches. These routings were made to determine downstream flooding characteristics. The flood depth, width and mean flow velocity of the four flood flows at the Borough of Old Tappan are summarized in the following tabulation:

	Flooding Characteristics at Old Tappan (Station 8)			
	25% PMF	50% PMF	75% PMF	PMF
Peak Discharge, cfs	4,160	9,100	14,360	19,750
Peak Flood Depth, ft.	10.4	13.9	16.5	18.6
Peak Flood Top Width, ft.	645	830	970	1,060
Peak Flow Velocity, fps	1.4	1.6	1.8	2.0

The drain outlet of Lake Tappan is 48-inches by 58-inches. The rating curve for the outlet was given in the as-built drawings for the dam. Using this rating curve and assuming no inflow into the lake, the time required to drain the reservoir from the spillway crest elevation was calculated to be about 9 days.

b. Experience Data

Records of lake levels are maintained for the site. The reservoir is operated to maintain maximum water levels for water supply purposes. The dam has never been overtopped.

c. Visual Observations

Upstream of the spillway there is an embankment for a road crossing. Near the middle of this embankment is a rectangular bridge opening through which all flows must pass. During large floods this constriction would alter peak discharges. However, the Corps requested that the effect of this embankment and bridge opening be ignored.

Downstream of the spillway the stream channel narrows to less than one-third of the spillway width. The cross-section of the main channel is approximately rectangular with low banks and does not appear capable of containing large flows. The flood plain, which would be inundated during high flows, is moderately sloping and heavily forested. No structures were observed immediately downstream of the dam.

d. Overtopping Potential

As indicated on Section 5.1-a, the spillway for Lake Tappan can handle discharges greater than the PMF; therefore, under current operating conditions, overtopping will not occur. In accordance with the Corps' Guidelines, the spillway should be classified as Adequate.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

At the time of the inspection, the dam appeared to be in good condition structurally and did not exhibit any signs of significant distress. Visual inspection revealed some cracking of the concrete gravity section of the dam and training walls, but these cracks do not appear to have any structural significance. Spalling noted at the top of the concrete piers, adjacent to the bridge deck, is not presently severe enough to affect the structural strength or stability.

The minor seep observed downstream of the right embankment does not appear to be detrimental to the stability of the structure and is possibly associated with drainage through the embankment toe drain.

The outlet works, spillway gates and operating equipment appear to be in good condition.

b. Design and Construction Data

The available design and construction data indicate that the concrete gravity section of the dam is adequately designed for its intended purpose. Insofar as is known, there are no stability or seepage analyses of the earth embankment and no data regarding the as-built properties of the earth fill.

c. Operating Records

Operating records showing the elevation of the reservoir and amount of opening of the individual bascule gates

are available for the following storms: June 18 to 20, 1971, February 1 to 4, 1973, September 25 to 28, 1975 and November 7 to 10, 1977.

Reservoir levels are recorded by an electric stage gage. Discharge through the gates and outlet works can be obtained using the graphs presented on Plates 6 and 8, respectively, if the reservoir elevation is known.

d. Post-Construction Changes

Flow splitters were installed at the top of the gates to change the harmonics of the flow so as to reduce downstream disturbance. Another post-construction change was the installation of mechanical stops on the gates to ensure that jamming of the gates would not occur during a flood. These post-construction changes are reportedly operating as intended.

e. Seismic Stability

Since the area lies within Seismic Zone 1, only minor damage may be expected from distant earthquakes. In general, projects located within Seismic Zone 1 may be assumed to present no hazard from earthquakes, provided static stability conditions are satisfactory and conventional safety margins exist. The stability analysis of the concrete section of the dam indicates that this section has satisfactory static stability, but an analysis would be required to verify the stability of the embankment section of the dam.

SECTION 7: ASSESSMENT, RECOMMENDATIONS, PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety

The Lake Tappan Dam spillway is adequate and is capable of passing the Probable Maximum Flood without the dam being overtopped.

The available as-built plans and stability analyses indicate that the concrete gravity section of the dam, including the outlet works, are adequately designed.

The safety of the embankments cannot be quantitatively analyzed due to lack of information regarding their construction and material properties. However, visual inspection indicates that the embankment is in good condition with no evidence of major stress, settlement or cracking.

b. Adequacy of Information

The available information and data are adequate to perform an evaluation of the structural design of the spillway section. The existing sliding and overturing stability analyses are adequate and indicate no potential instability.

There are insufficient data to evaluate the dam foundation pressures, presented on Plate 4. In addition, there are insufficient data to perform a comprehensive, definitive evaluation of the stability of the embankments.

c. Urgency

The visual inspection revealed no apparent deficiencies

that would imperil the short-term integrity of the structure. Certain recommendations are suggested, the most urgent being investigation of the seepage at the right embankment, which should be implemented very soon. Other recommendations are of a less urgent nature and should be implemented as soon as possible.

d. Necessity for Additional Data/Evaluation

At the present time there is insufficient information available to fully evaluate the stability of the embankment sections of the dam. The construction specifications indicate that construction inspection reports including compaction control tests of the embankment material were to be performed. This information was not made available by the owner for this Phase I study. It is, therefore, recommended that these data be obtained and reviewed together with internal water level measurements obtained from the piezometers in order to perform stability and seepage evaluations of the embankments.

7.2 Remedial Measures

a. Recommendations

It appears that the seep noted downstream of the right embankment, adjacent to the training wall, possibly originates as discharge from the drain along the downstream toe of the embankment. This should be confirmed very soon by excavating the soil in the vicinity of the seep to expose the toe drain exit shown in Plate 9. If the seep is a result of water discharging from the toe drain, the soil covering the drain exit should be removed or replaced with free draining material to facilitate the flow of water from the drain.

b. Operation and Maintenance Procedures

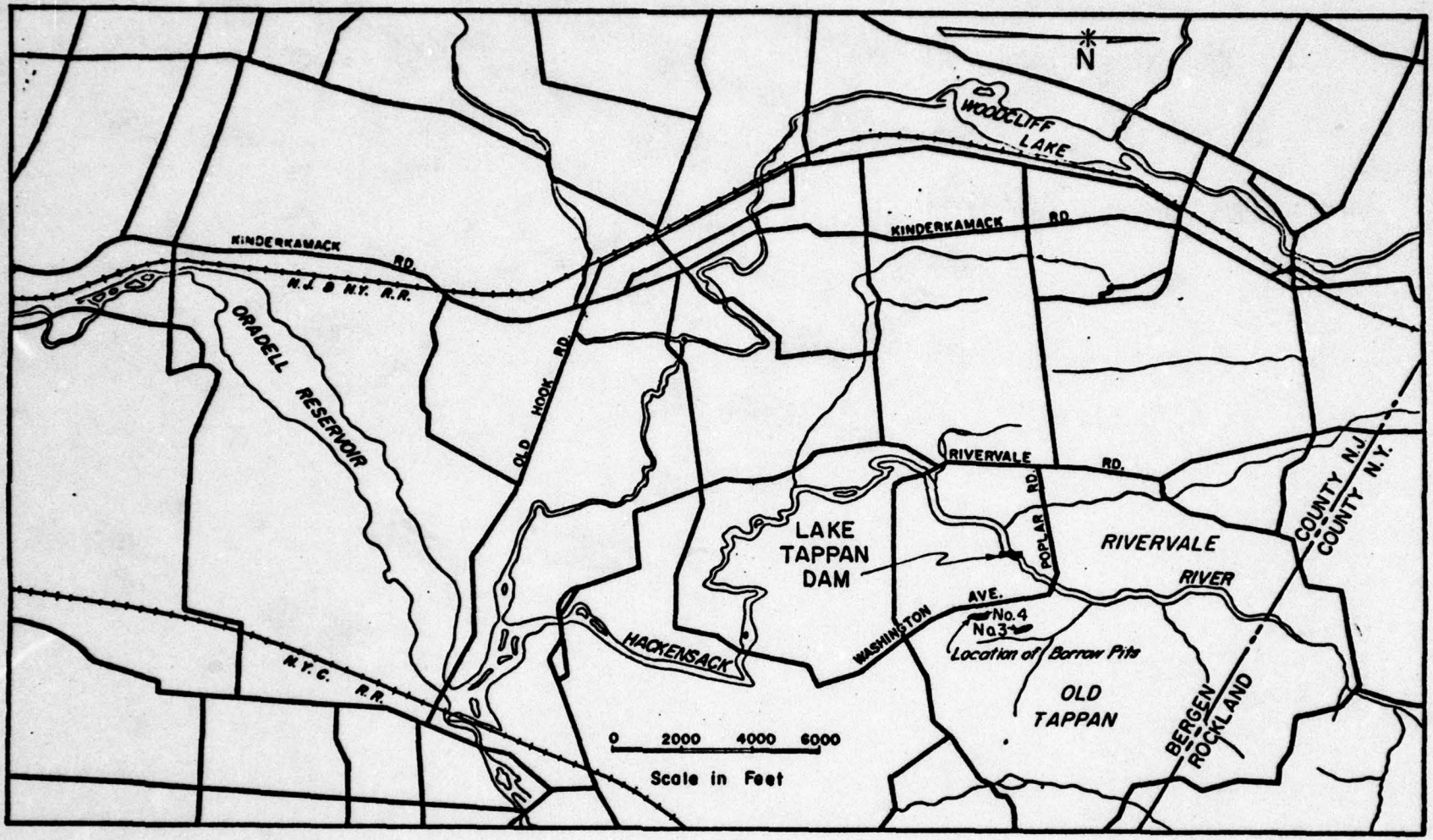
A program of annual inspections of the dam should be initiated by the owners, utilizing the standard visual check list in this report.

The cracks in the concrete gravity section and training walls and the spalling at the tops of the concrete piers do not appear to affect the structural stability of the dam These cracks and spalls should be periodically inspected in order to detect any movement or deterioration. In addition, any leakage through the cracks into the inspection gallery should be monitored and remedial work performed on the cracks, should leakage become excessive. Measures should be taken to drain the inspection gallery and keep it drained to facilitate inspection.

The top of the piezometer located on the upper section of the left embankment should be repaired as soon as possible. All four piezometers should be monitored regularly and the phreatic water levels recorded and plotted to detect any irregularities in the internal drainage.

A warning system should be established whereby downstream inhabitants may be quickly notified and evacuated in the event of possible dam failure.

PLATES



AREA LOCATION

VICINITY MAP

JENNY-LEEDSHILL JANUARY 1979

PLATE 1

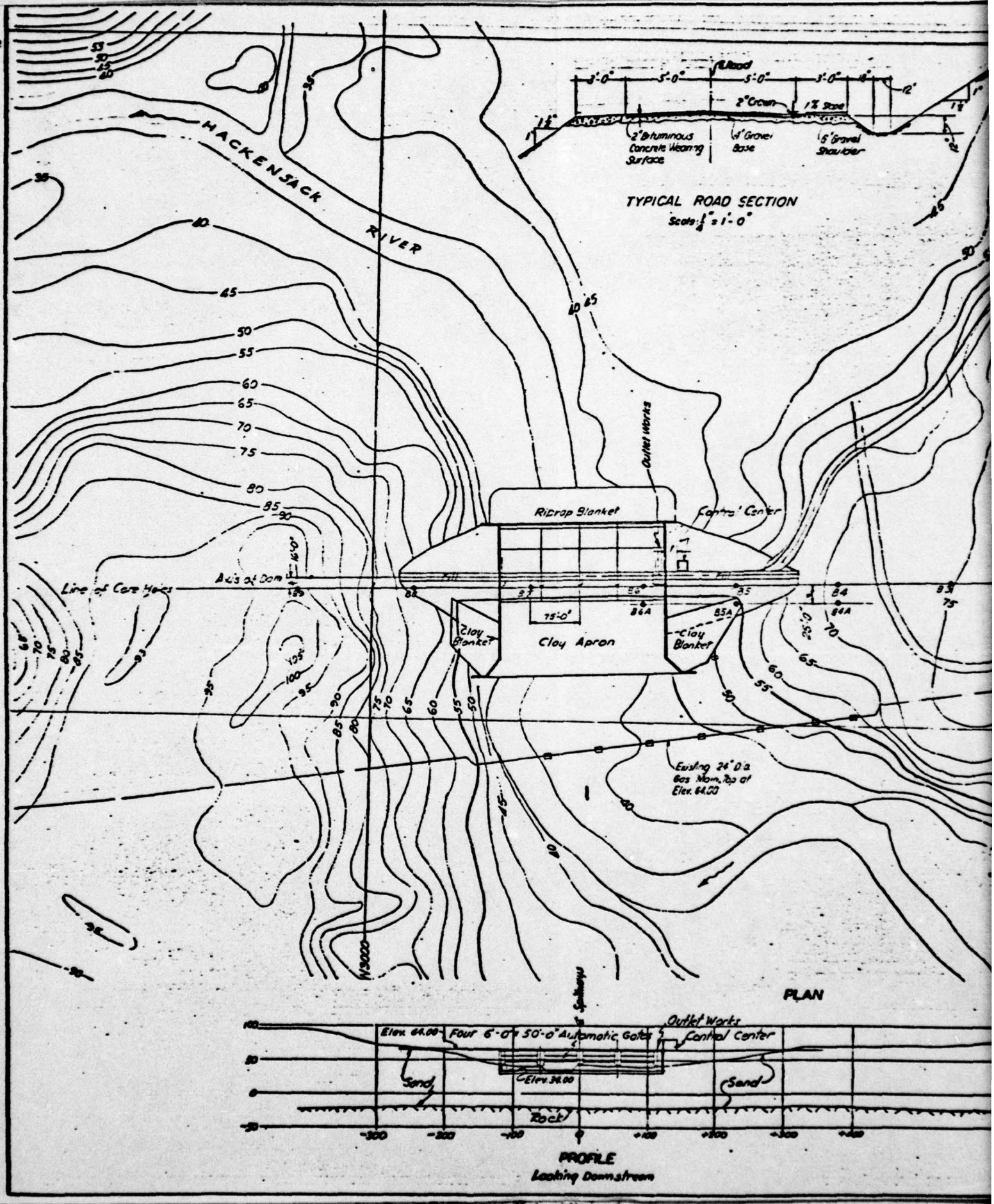

HACKENSACK RIVER
TYPICAL ROAD SECTION
Scale: 1/4" = 1'-0"
2" Bituminous Concrete Wearing Surface
4" Gravel Base
6" Gravel Shoulder
2% Crown
1% Slope
Riprap Blanket
Cente' Center
Outlet Works
Axis of Dam
Line of Core Holes
Clay Blanket
Clay Apron
75'-0"
Existing 24" O.D. Gas Main, Top at Elev. 64.00
PLAN
Outlet Works
Control Center
Elev. 64.00
Four 6'-0" x 50'-0" Automatic Gates
Elev. 34.00
Sand
Rock
PROFILE
Looking Downstream

PLATE 2

DRAWING NO. 400.27-11

HACKENSACK WATER COMPANY

NEW JERSEY DAM NO. 3

RIVERVALE-OLD TAPPAN, NEW JERSEY

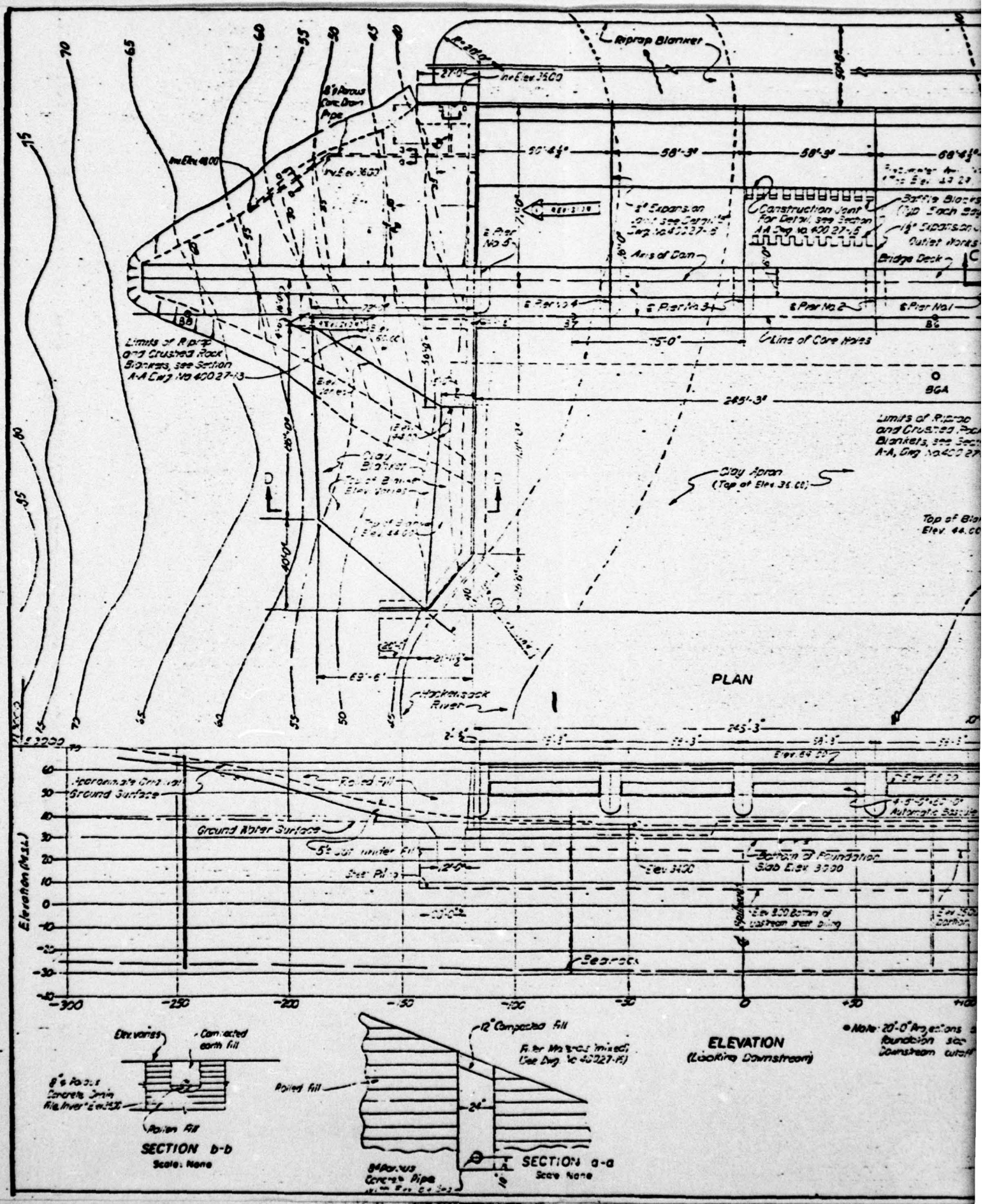
LOCATION PLAN

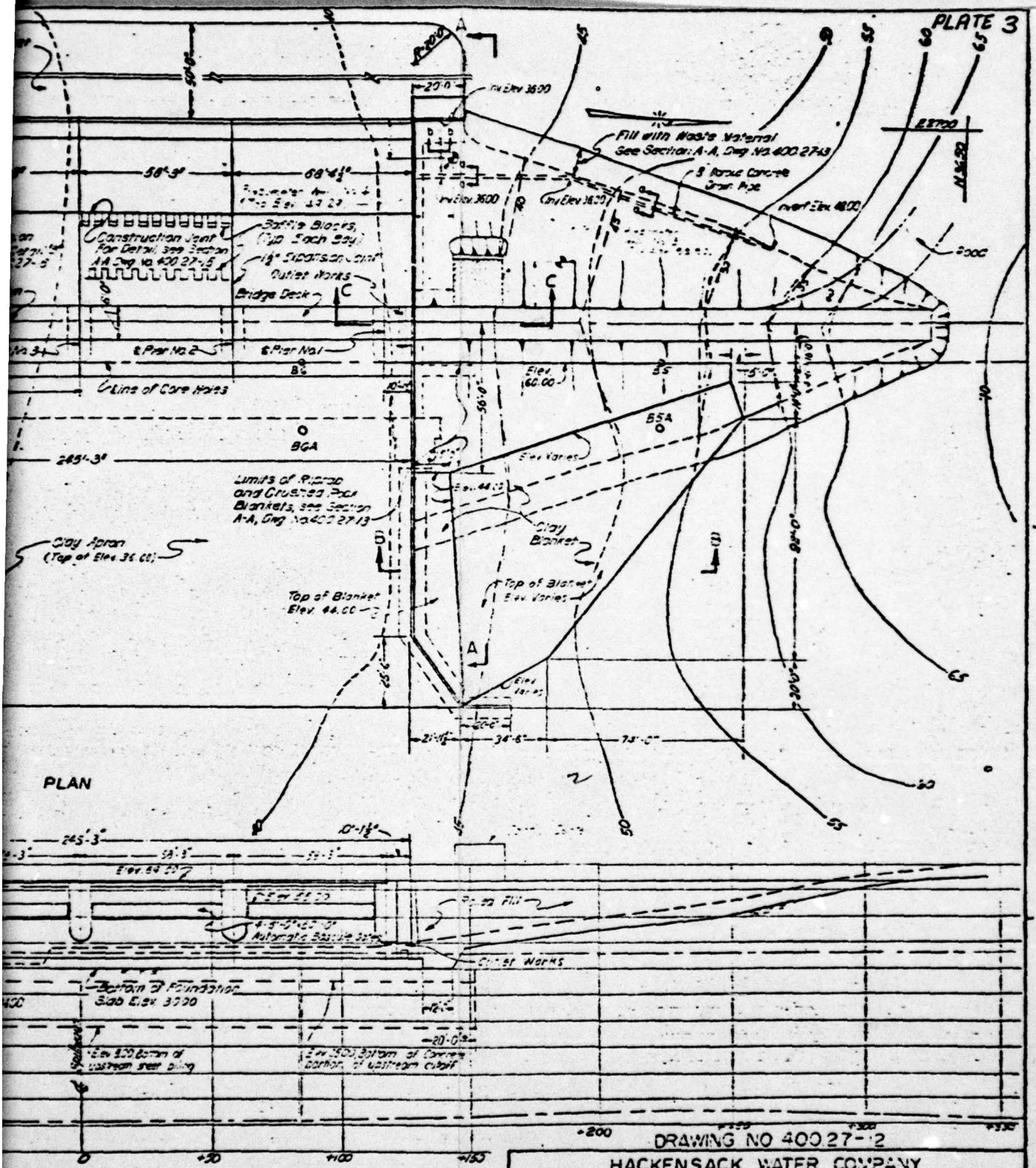
Buch, Seifert and Jost
Consulting Engineers
Englewood Cliffs, New Jersey

Scale: 1"=100'

October, 1964

Drawn by	Traced by	Checked by	Examined by	Approved By
JSG		LFL		
Revisions:	10-11-2-65			AS BUILT


Riprap Blanket
Inv Elev 3500
8'ø Arrow Conc Drain Pipe
Inv Elev 4800
Inv Elev 3607
Limits of Riprap and Crushed Rock Blankets, see Section A-A Dwg No 400 27-13
Clay Blanket
Top of Blanket Elev Varies
Top of Blanket Elev 44.00
Hackensack River
Clay Apron (Top of Elev 36.00)
Top of Blanket Elev 44.00
Axis of Dam
Construction Joint For Detail See Section A-A Dwg No 400 27-5
Bridge Deck
Outlet Works
Line of Core Holes
BGA
PLAN
Approximate Original Ground Surface
Rolled Fill
Ground After Surface
Sand Filter
Steel Piling
Bottom of Foundation Slab Elev 3000
Bedrock
Elevation (MSL)
Elevations
Corrected earth fill
Rolled Fill
SECTION b-b
Scale: None
12" Compacted Fill
Filter Materials mixed (See Dwg No 400 27-F)
SECTION a-a
Scale: None
ELEVATION
(Looking Downstream)



DRAWING NO 400.27-2

HACKENSACK WATER COMPANY

NEW JERSEY DAM NO. 3

RIVERVALE-OLD TAPPAN, NEW JERSEY

DAM

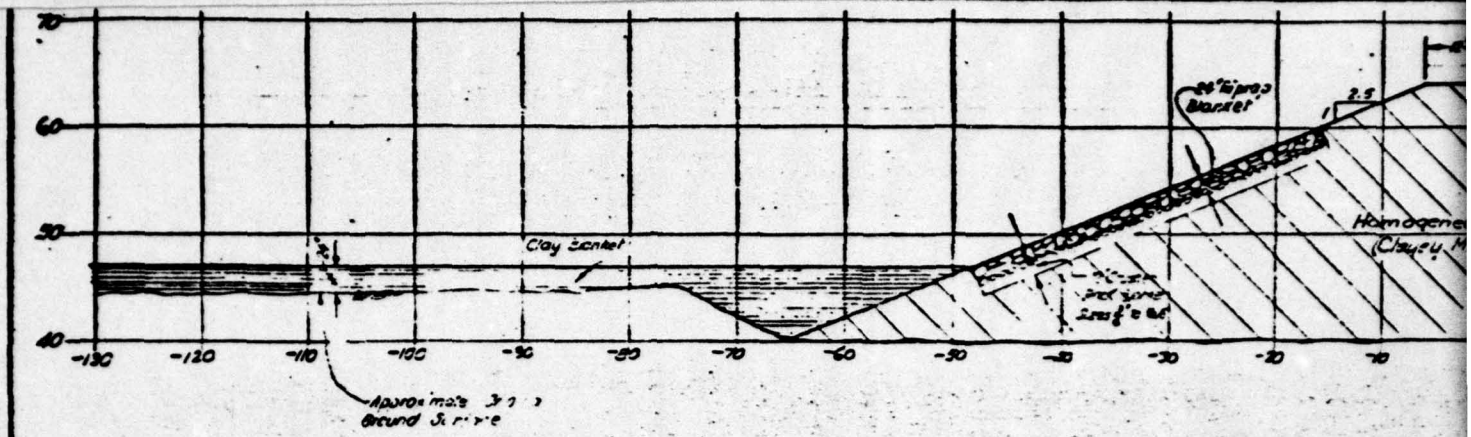
Buck, Seifert and Jost
Consulting Engineers
Englewood Cliffs, New Jersey

Scale: 1" = 30'

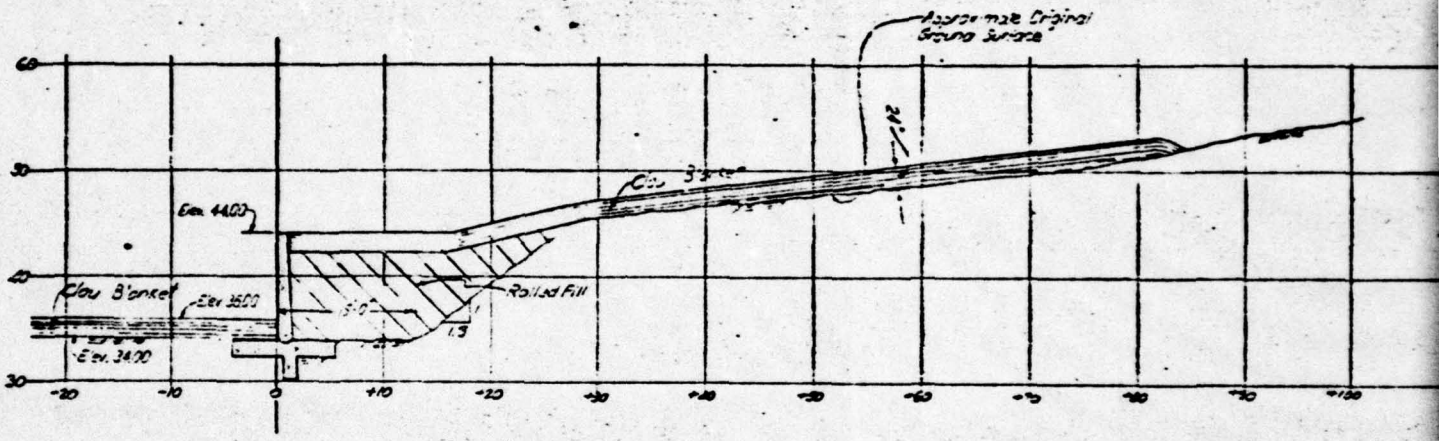
October, 1964

Drawn by: JSC | Traced by: | Checked by: | Approved by:

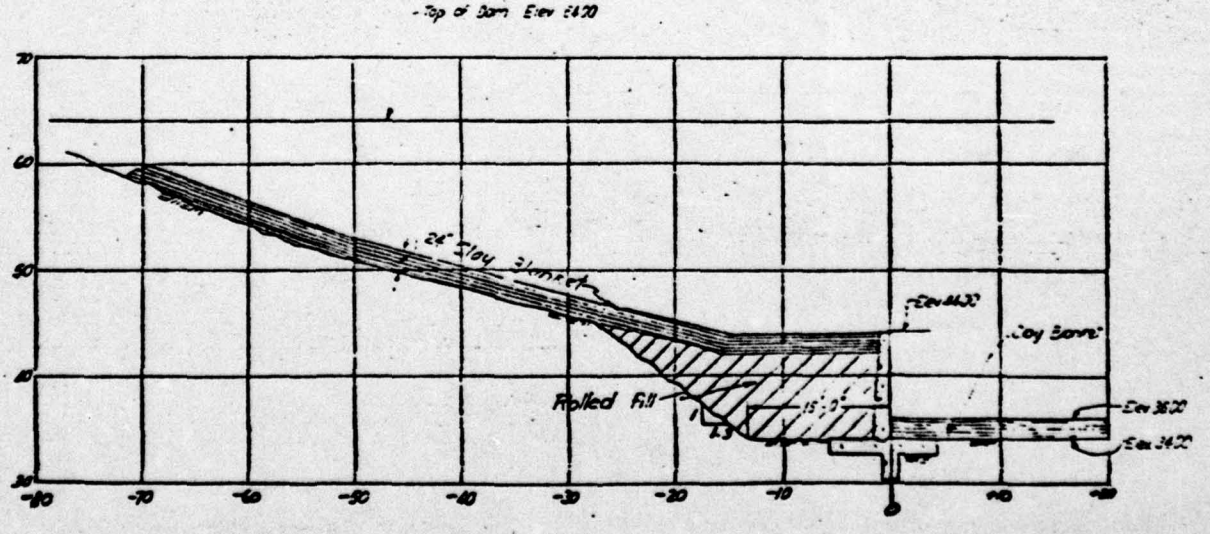
Revisions: (1) 11-2-65



SECTION A-A



SECTION B-B



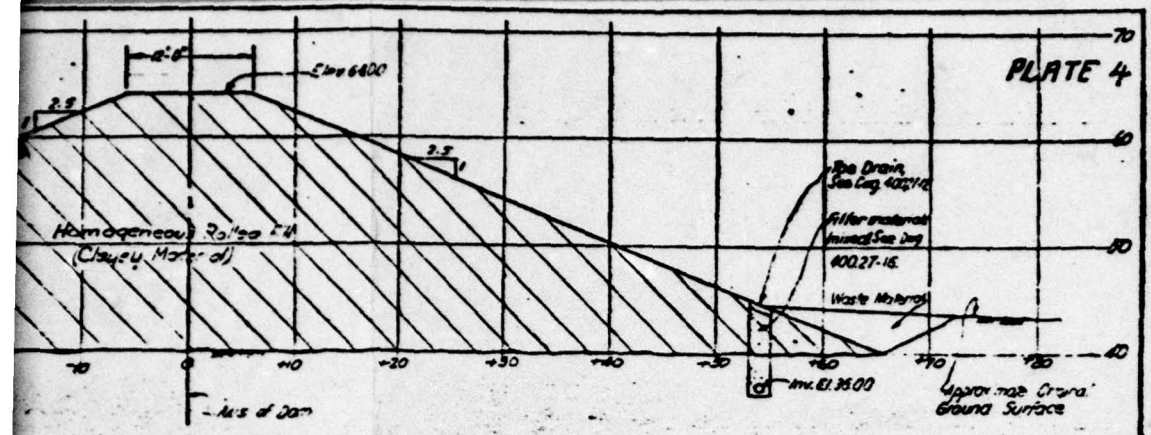
SECTION D-D

RESERVOIR WATER SURFACE ELEVATION	CO	
	GATES	TA EL
36.00 (empty)	–	
36.00	–	
55.00	Up	
55.00	Up	
55.00	Down	
55.00	Down	
57.00	Down	
62.00	Down	

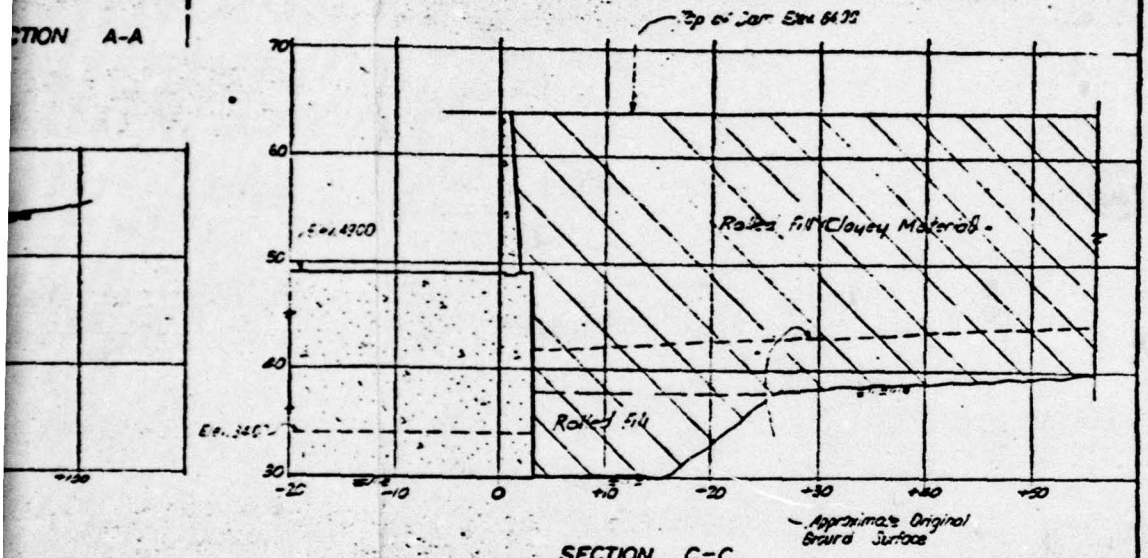
Note:
* All F
Comp

DAM FOUND

PLATE 4



SECTION A-A



SECTION C-C

2

RESERVOIR WATER SURFACE ELEVATION	CONDITION			FOUNDATION BEARING PRESSURES (PSI) *		SLIDING COEFF. ϕ
	GATES	TAILWATER ELEVATION	EARTHQUAKE INDUCED MOTION	HEEL	TOE	
46.00 (Masonry)	–	36.00 (Ground Level)	None	1108	752	0
46.00	–	" "	Heel to Toe	1122	718	0.07
45.00	Up	36.00	None	1501	327	0.172
45.00	Up	36.00	Heel to Toe	1553	290	0.105
43.00	Down	44.50	None	1162	328	0.143
43.00	Down	44.50	Heel to Toe	1197	293	0.061
47.00	Down	46.30	None	1101	373	0.158
42.00	Down	42.40	None	1166	326	0.183

1. Sliding Resistance due to Projections cutoffs and Downstream Slab not included.
2. Includes Effect of uplift derived from Flow Nets.

Note:
* All Foundation Pressures are Compressive Pressures on Soil.

DAM FOUNDATION PRESSURES

1

DRAWING NO. 400 27-13

HACKENSACK WATER COMPANY

NEW JERSEY DAM NO. 3
RIVERVALE-OLD TAPPAN NEW JERSEY

SECTIONS

Buck, Seifert and Jost
Consulting Engineers
Englewood Cliffs, New Jersey

Scale 1"=10' October, 1964

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Revisions:	① - 11-2-65			AS BUILT

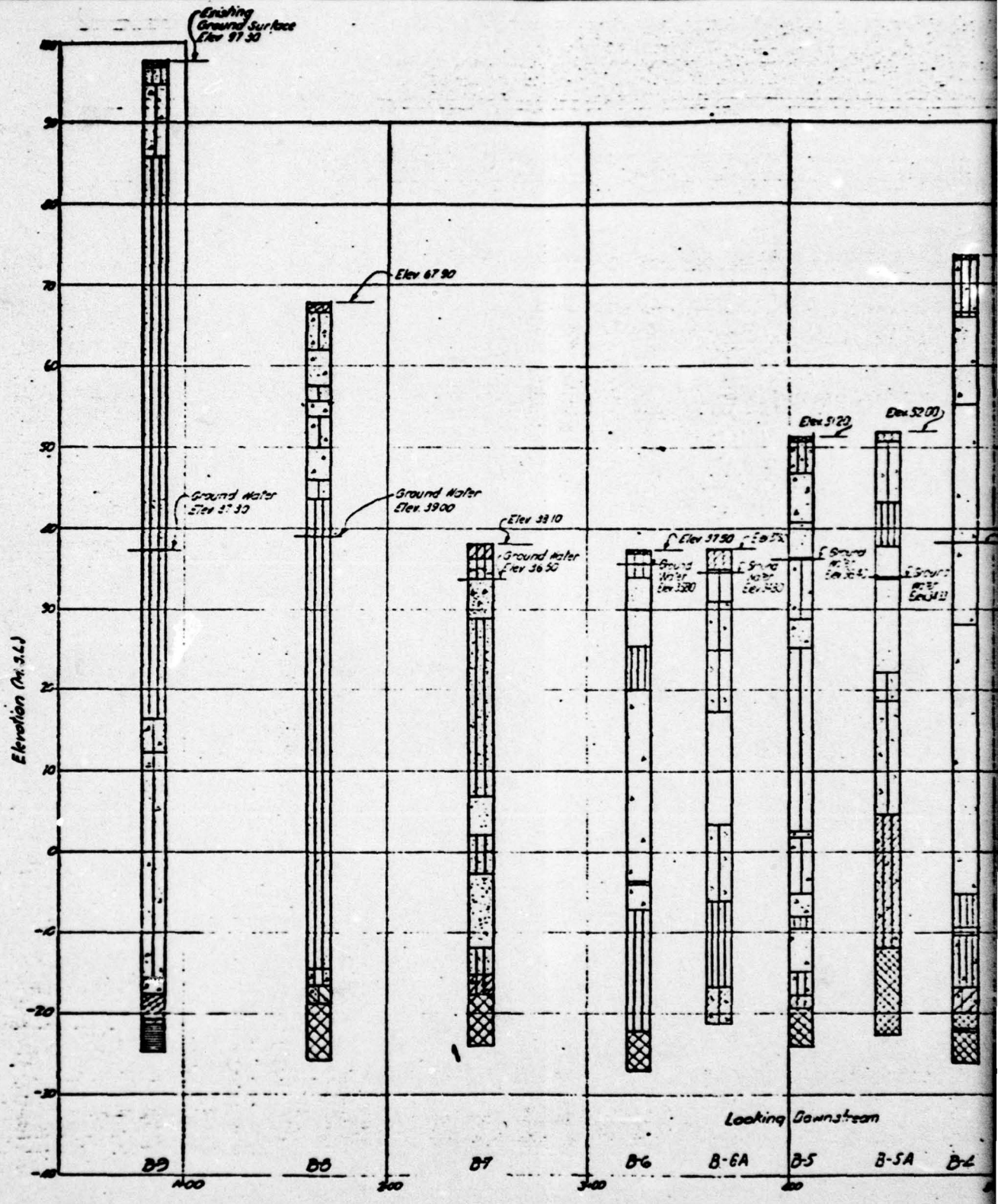
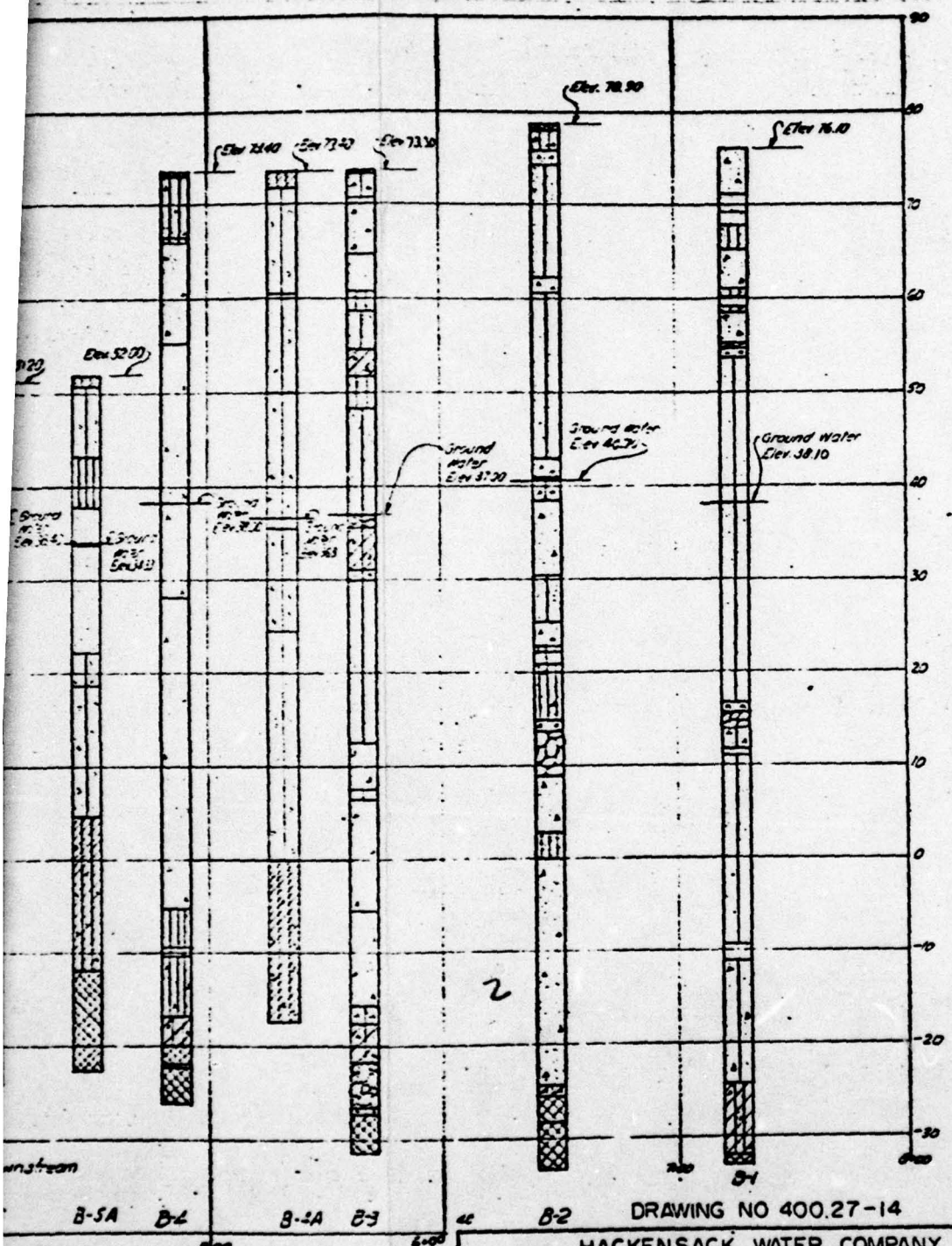

Existing Ground Surface Elev 97.30
Elev 67.90
Elev 52.00
Ground Water Elev. 39.00
Elev 39.10
Ground Water Elev. 36.50
Elev 37.90
Looking Downstream
B-9
B-8
B-7
B-6
B-6A
B-5
B-5A
B-4
Elevation (Ft. M.L.)
Top soil (1 to 6") silt, sand, clay, organic.
Green brown sand & silt. (also bottom 12" of top soil)
Light brown, dark red, med. dense sand, trace of silt, trace of gravel
Brown, med. dense, very fine sand & silt, trace of med. sand.
Clayey, very dense, red to brown, fine to med. sand & silt. Shale fragments
Brown, dense fine, very fine sand & trace of silt.
Brown, very dense, med. coarse sand
Boulders.
Brown rock, soft to med. hard, whole, lam
Dark brown, soft shale rock.
Light brown hard sandstone.
Brown med. dense to dense, fine to coarse
Brown to red, dense to very dense, coarse
clay and gravel.

PLATE 5



DRAWING NO 400.27-14

...nse, med. coarse sand with med. gravel.

...ft to med. hard, whole, laminated, fine cracks.

...oft shale rock.

...ard sandstone.

...se to dense, fine to coarse sand with some fine to med. gravel.

...nse to very dense, coarse to fine sand and silt, little ...

HACKENSACK WATER COMPANY

NEW JERSEY DAM NO. 3

RIVERVALE - OLD TAPPAN NEW JERSEY

EXPLORATION LOGS

Buck, Seifert and Jost
Consulting Engineers
Englewood Cliff, New Jersey

Scale: As Shown | October, 19...

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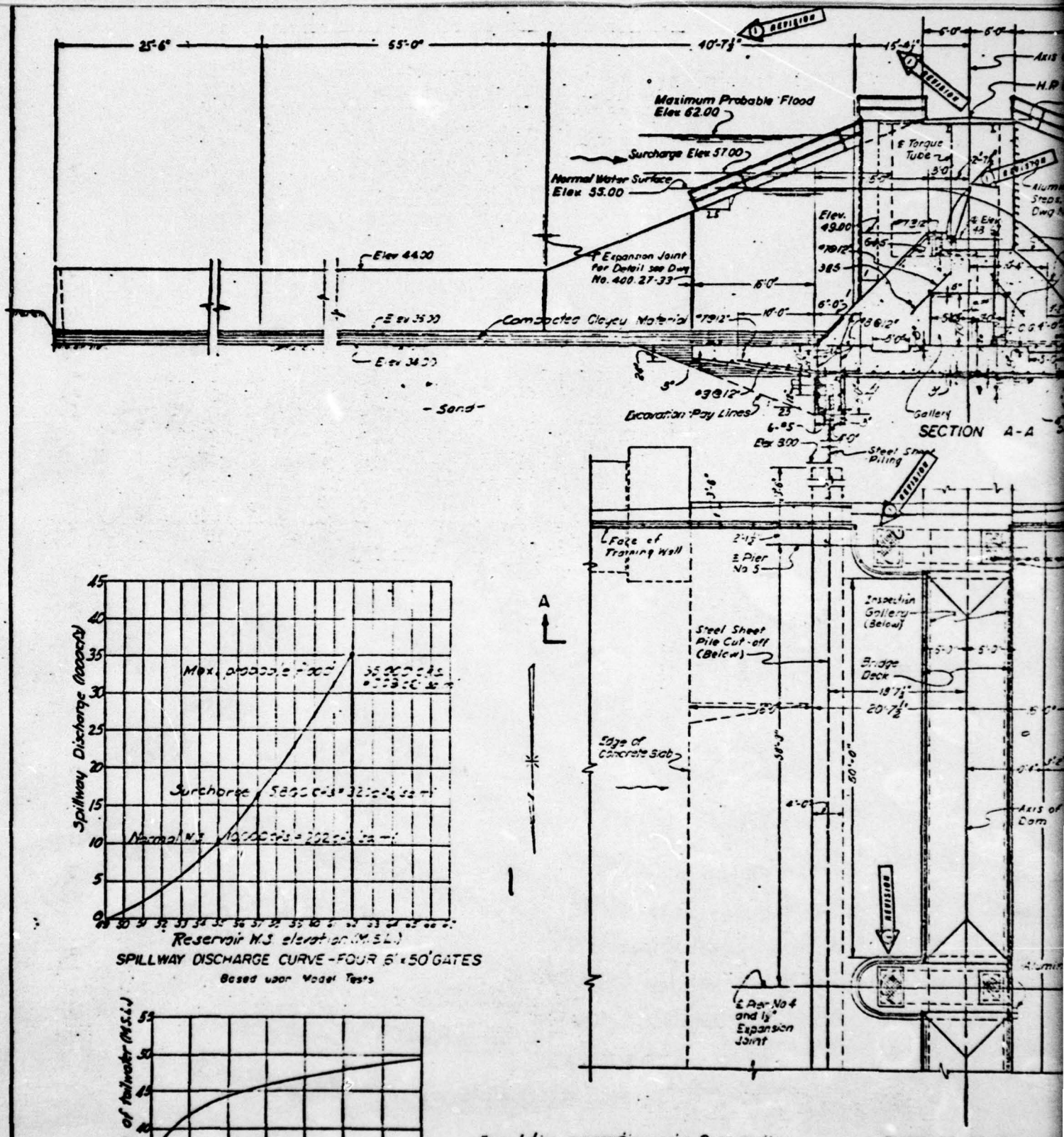
Revisions:	①-11-2-65			AS BUILT



SPILLWAY DISCHARGE CURVE - FOUR 5' x 50' GATES

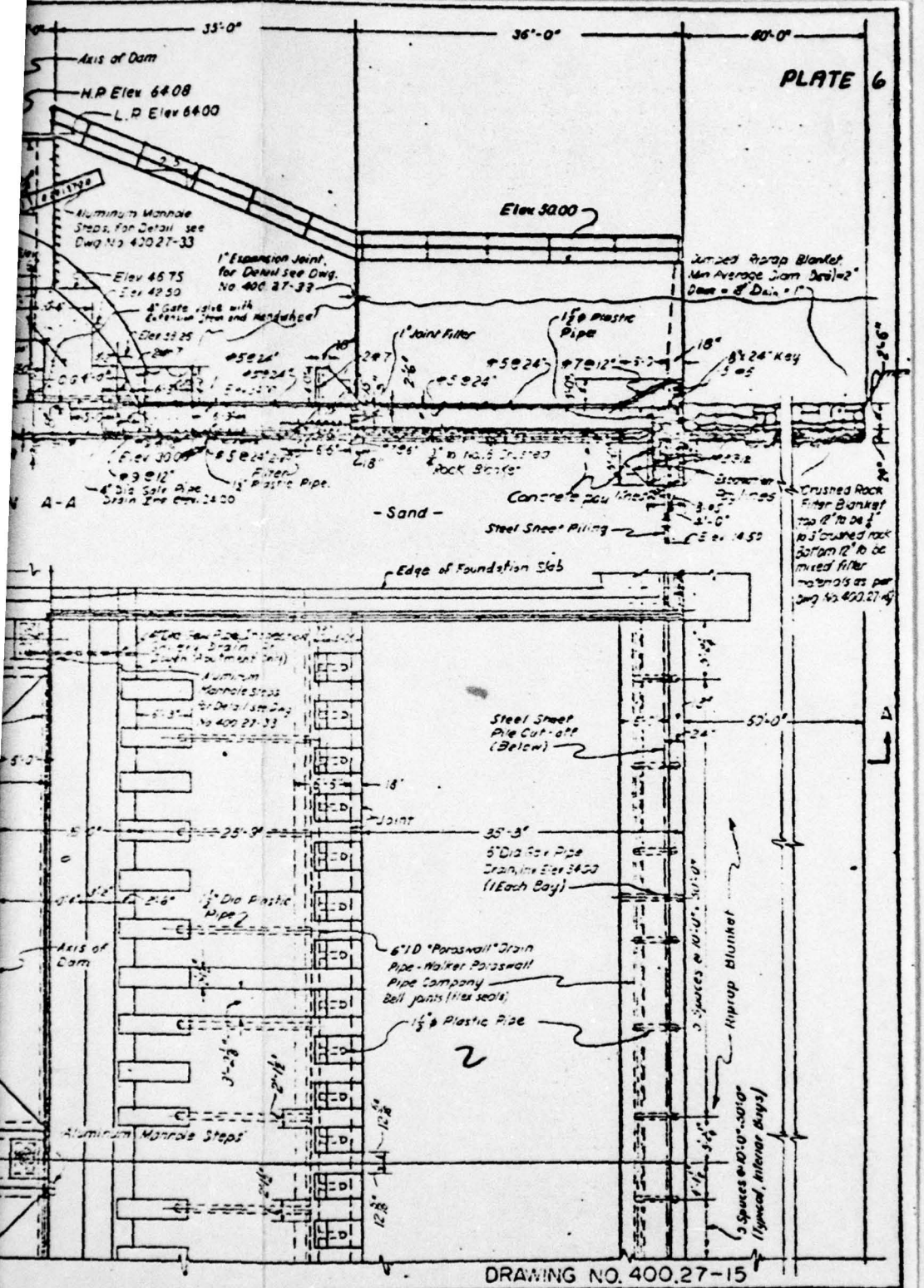
Based upon Model Tests

TAILWATER CURVE

Foundation preparation under Ogee section:
1. Compact foundation.
2. Add material, if required, to bring up to grade.
3. Recompact foundation.
4. Scarify foundation 3" deep in direction of Axis of Dam

* Ave. weight/foot (inc. pier roots)

PLATE 6



DRAWING NO. 400.27-15

SOUTH ABUTMENT

HACKENSACK WATER COMPANY

NEW JERSEY DAM NO. 3

RIVERVALE-OLD TAPPAN, NEW JERSEY

DIMENSIONS AND REINFORCING

Buck, Seifert and Jost
Consulting Engineers
Englewood Cliffs, New Jersey

Scale: 1"=10' | October, 1964

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Revisions:	① 11-2-65			AS BUILT

Conc. piers 90 cu. yds. deck = 94 sq. ft.

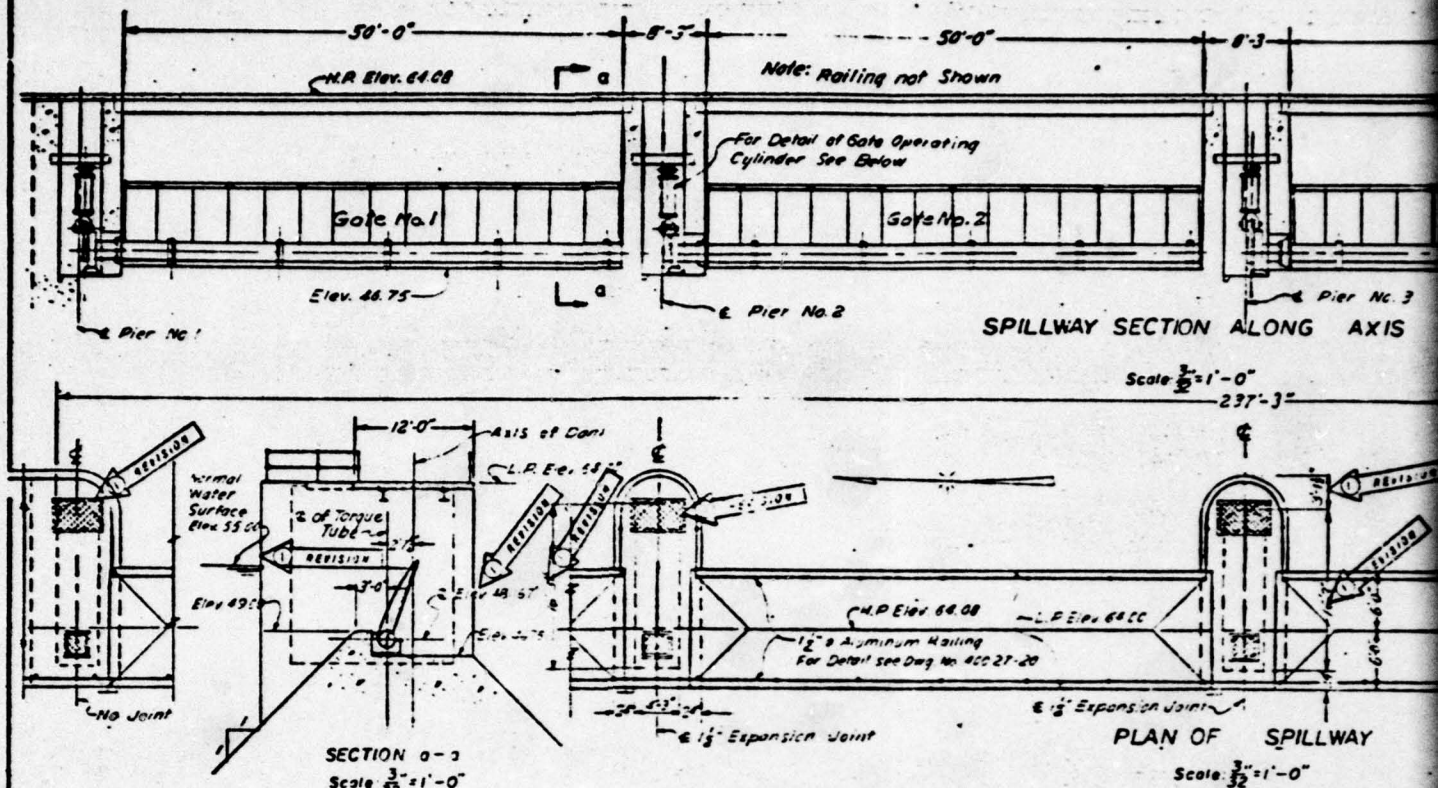
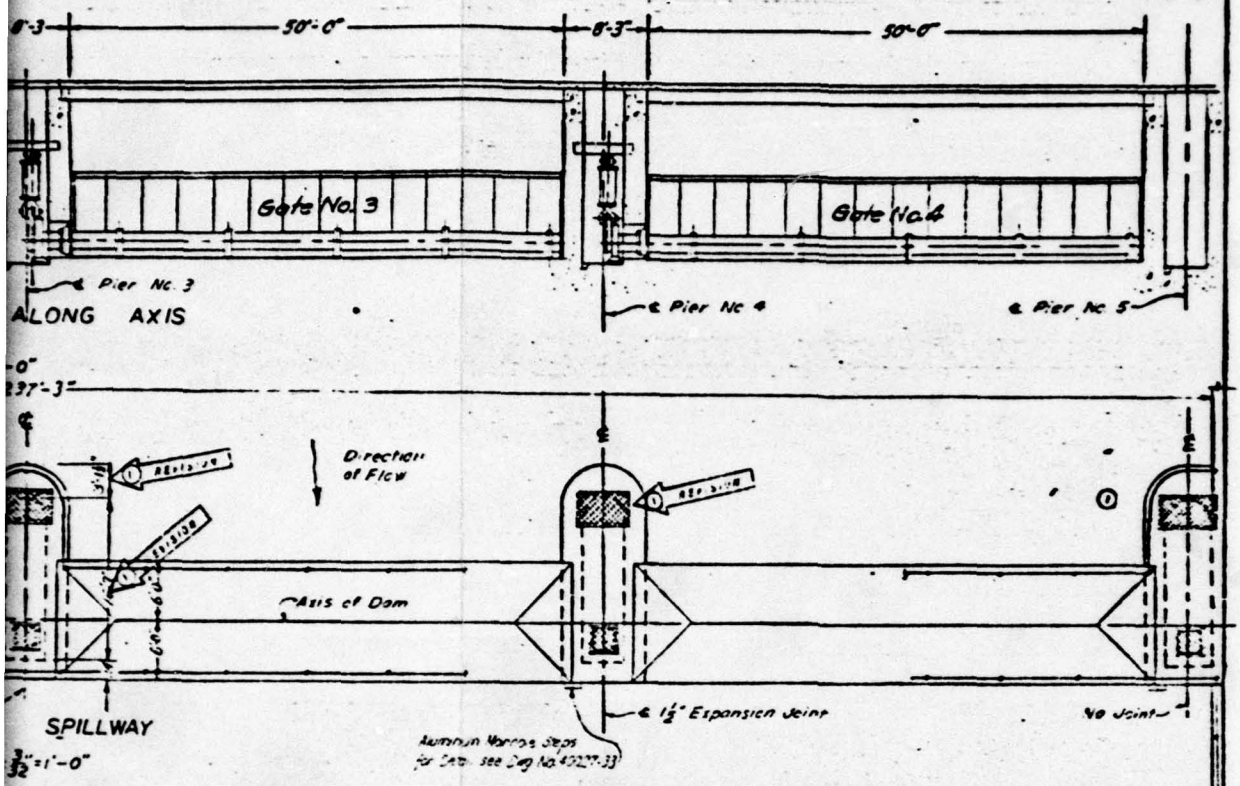
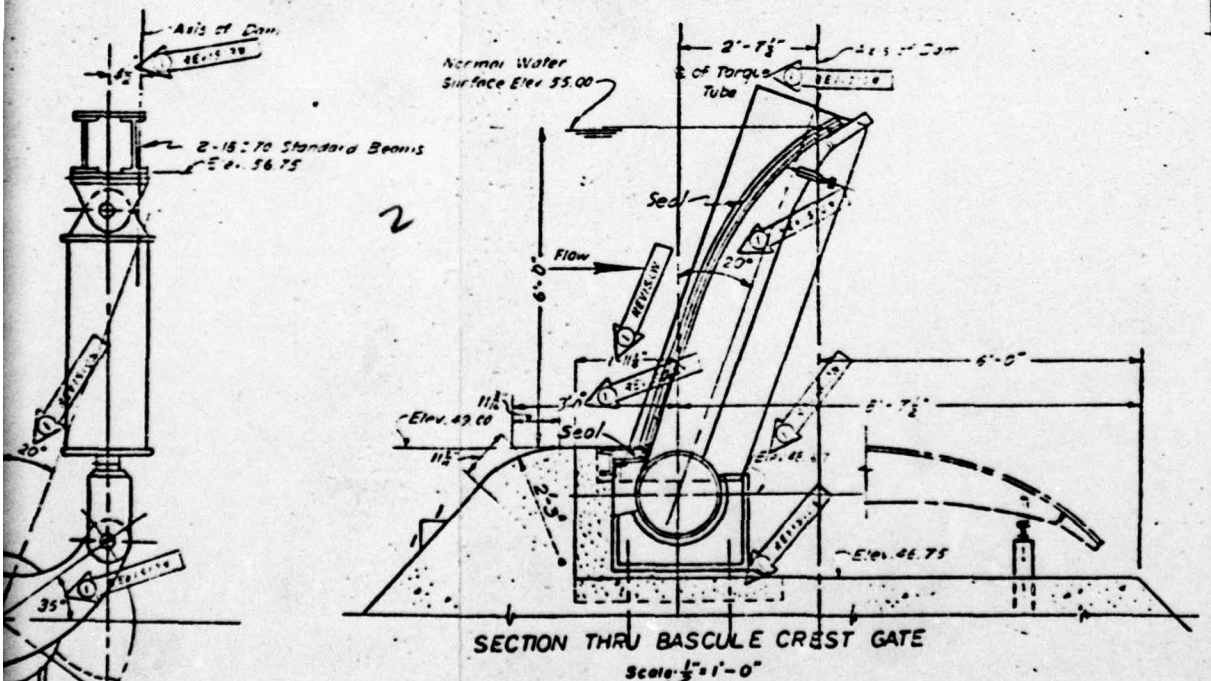

50'-0"
8'-3"
50'-0"
8'-3
H.P. Elev. 64.08
Note: Railing not Shown
For Detail of Gate Operating Cylinder See Below
Gate No. 1
Gate No. 2
Elev. 46.75
℄ Pier No. 1
℄ Pier No. 2
℄ Pier No. 3
SPILLWAY SECTION ALONG AXIS
Scale 3/32"=1'-0"
237'-3"
12'-0"
Axis of Dam
Normal Water Surface Elev. 55.00
℄ of Torque Tube
Elev 49.50
REVISION
No Joint
SECTION a-a
Scale 3/32"=1'-0"
H.P Elev 64.08
L.P Elev 64.00
1/2" ø Aluminum Railing
For Detail see Dwg No. 400 27-20
℄ 1 1/2" Expansion Joint
PLAN OF SPILLWAY
Scale 3/32"=1'-0"
24"
5'-3"
24"
Elev. 56.75
Normal Water Surface Elev. 55.00
45°
℄ 51 Torsion Cylinder Elev 48.167
Drain Gutter
Elev 45.67
Elev. 46.75
1 1/2" Expansion Joint
SPILLWAY SECTION ALONG AXIS
Flow
20°
35°
Elev
2'-3"
SECTION b-b
DETAIL OF GATE OPERATING CYLINDER
Scale 1"=1'-0"

PLATE 7





Note:
Details of Bascule Gate and Gate Operating Cylinder are based on Allis-Chalmers Mfg Co. design.

DRAWING NO. 40227-17

HACKENSACK WATER COMPANY

NEW JERSEY DAM NO. 3

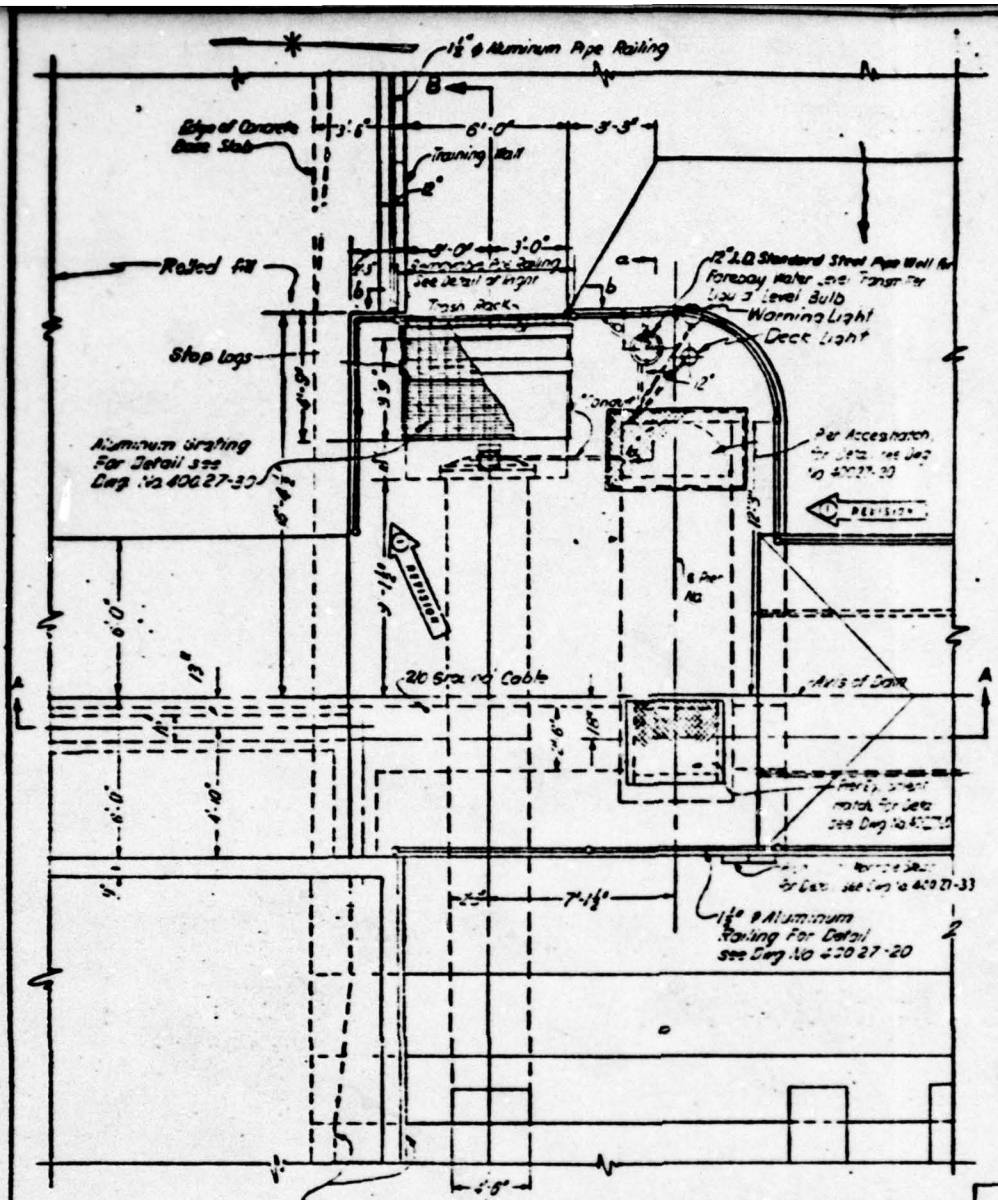
RIVERVALE-OLD TAPPAN, NEW JERSEY

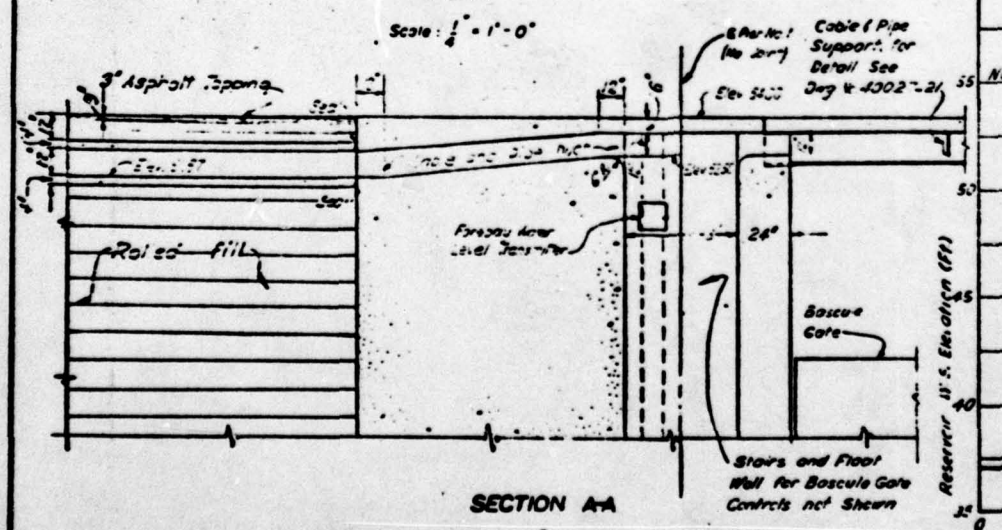
SPILLWAY

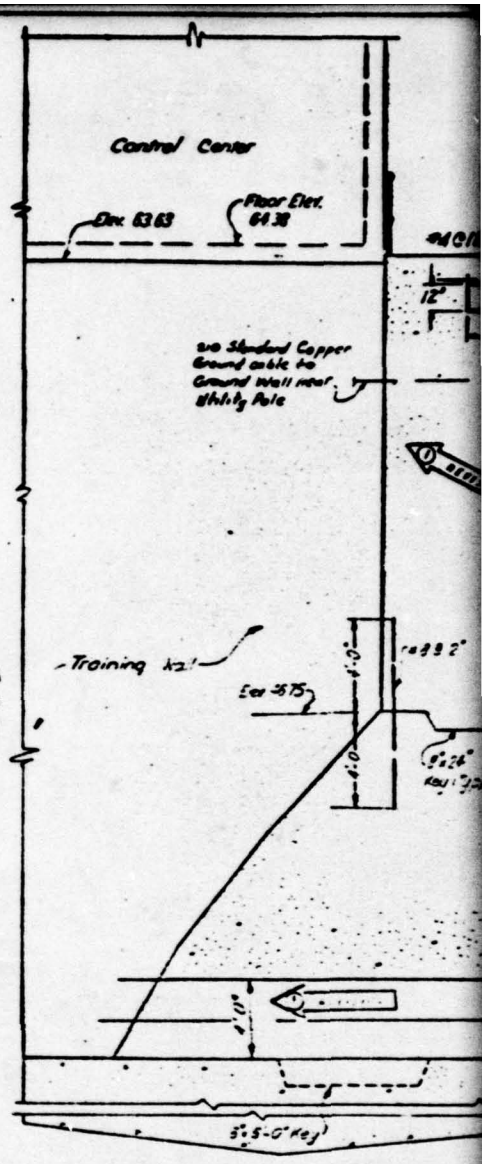
Buck, Seifert and Jost
Consulting Engineers
Englewood Cliffs, New Jersey

Scale: As Shown | October, 1964

Drawn by: JSC	Traced by:	Checked by:	Examined by:	Approved by:
Revisions	① 11-2-65			AS BUILT


1½" ϕ Aluminum Pipe Railing
Edge of Concrete Base Slab
Training Wall
Raised Fill
Step Logs
Aluminum Grating For Detail See Dwg. No 400 27-33
12" S.D. Standard Steel Pipe Well for Freeway Water Level Transmitter
Warning Light
Deck Light
Per Accession
REVISION
20 Str. rd Cable
Axis of Door
1½" ϕ Aluminum Railing For Detail See Dwg. No 400 27-20
PLAN
Scale: ¼" = 1'-0"


3" Asphalt Topping
Raised fill
Freeway Water Level Transmitter
Bascule Gate
Stairs and Floor Well for Bascule Gate Controls not Shown
SECTION A-A
Scale: ¼" = 1'-0"


Control Center
Floor Elev. 64.38
Elev. 63.63
#4 Str. Standard Copper Ground cable to Ground Wall near Utility Pole
Training Wall
Elev. 45.75
5'x5'-0" Key

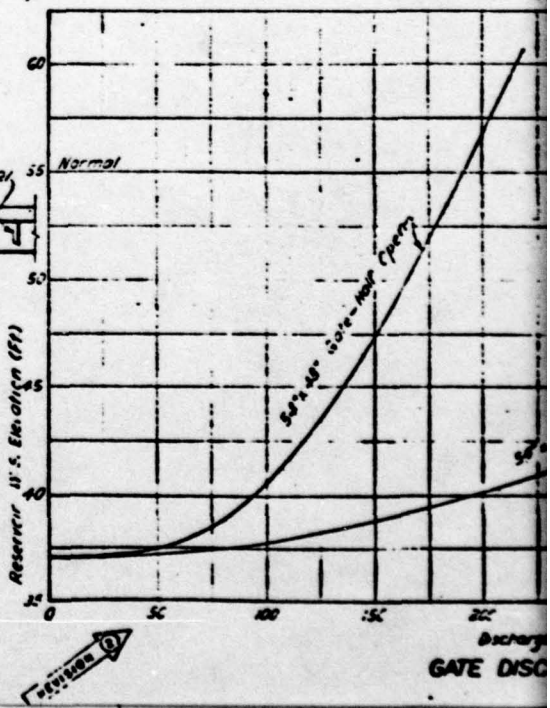
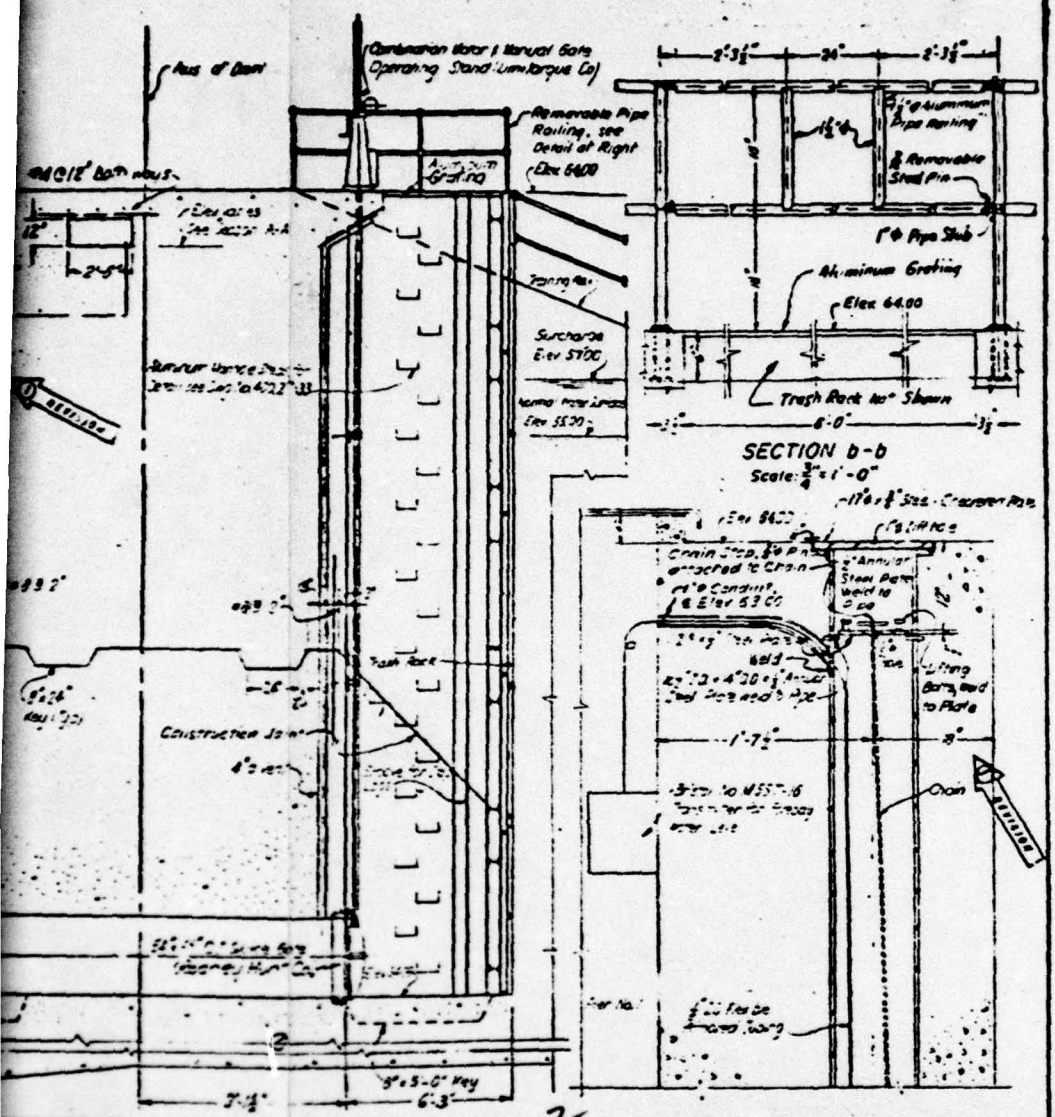

Normal
Reservoir W.S. Elevation (Ft)
Discharge
GATE DISC

PLATE 8



DRAWING NO. 400.27-29

HACKENSACK WATER COMPANY

NEW JERSEY DAM NO 3

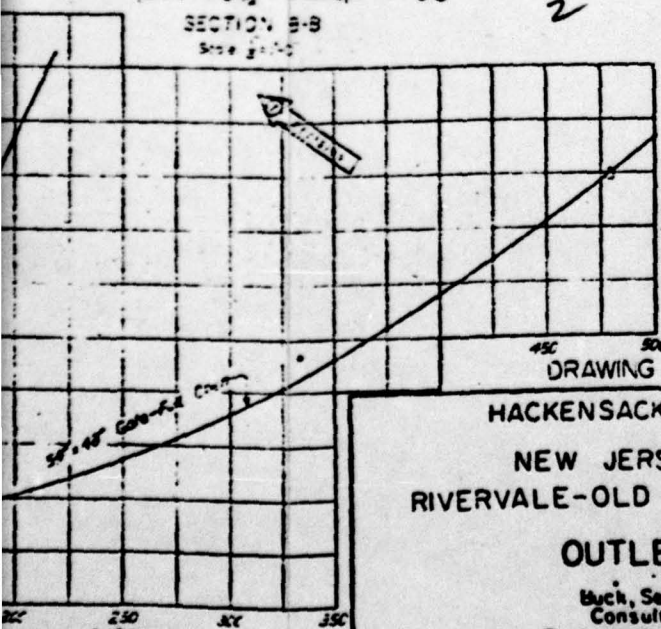
RIVERVALE-OLD TAPPAN, NEW JERSEY

OUTLET WORKS

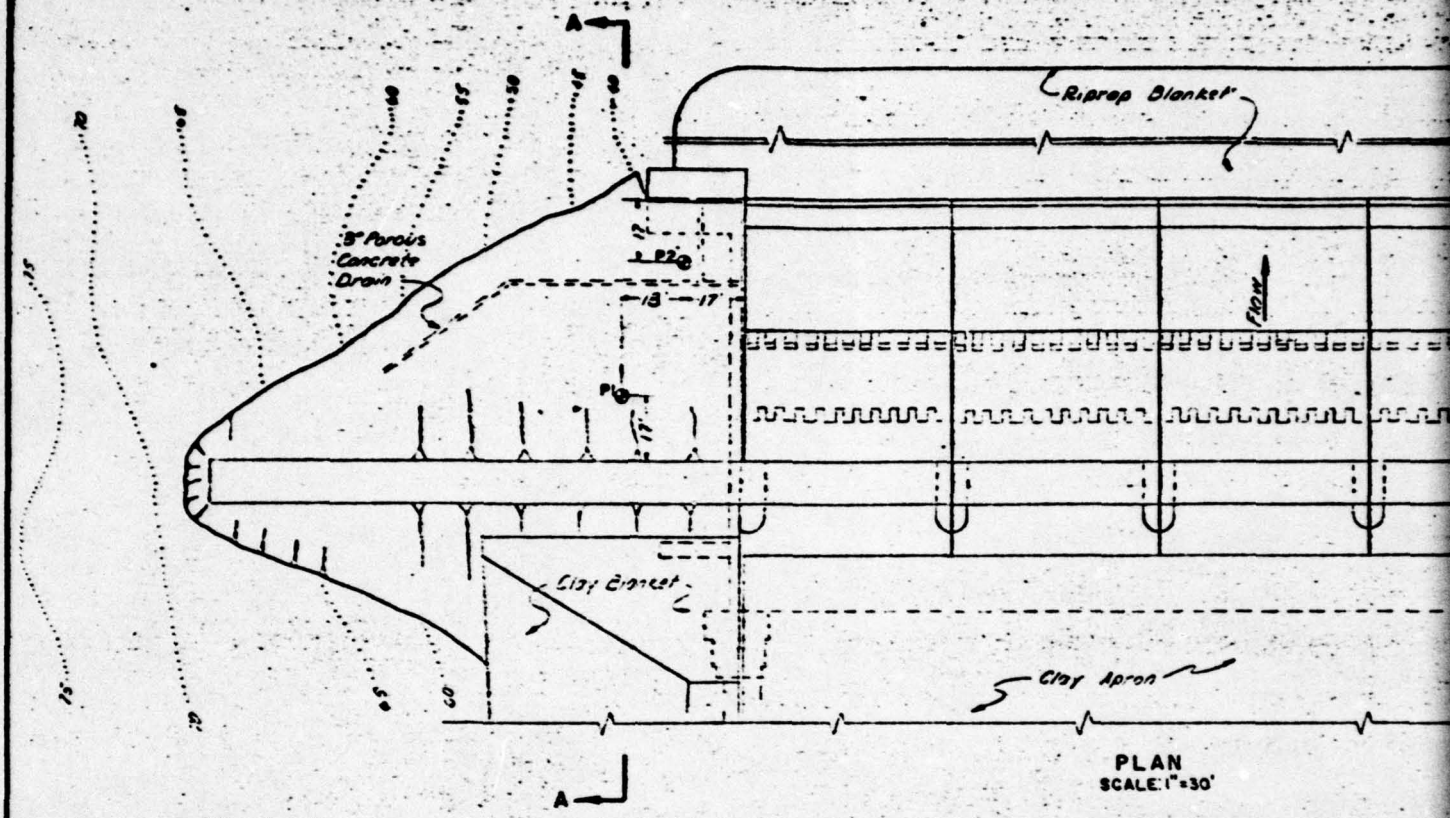
Buck, Seifert and Jost.
Consulting Engineers
Englewood Cliffs, New Jersey

Scale As Shown | October, 1964

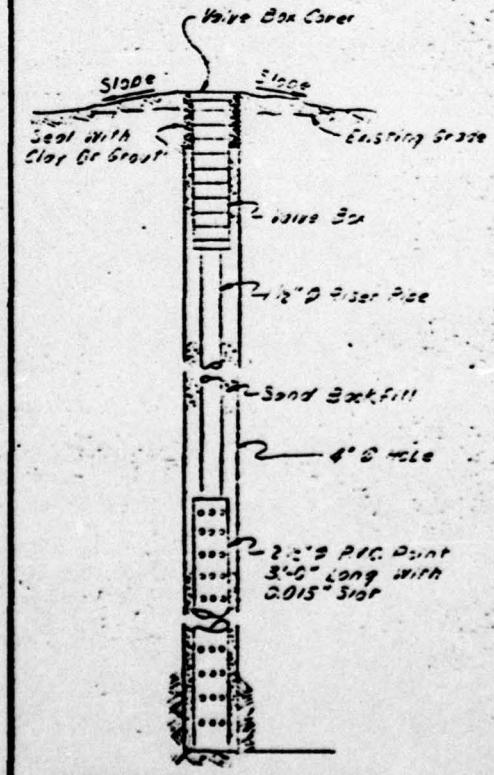
Drawn by:	Traced by:	Checked by:	Examined by:	Approved by:
Revisions:	① 11-2-66	② 9-2-66		AS BUILT



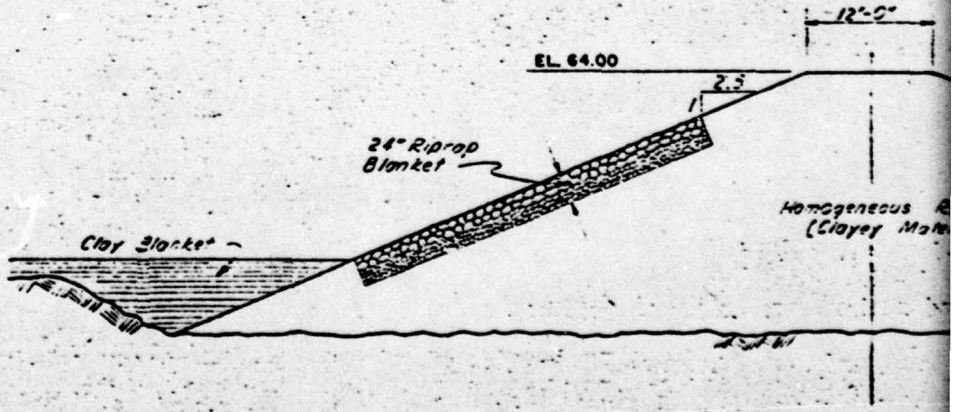
E DISCHARGE CURVES



PLAN
SCALE: 1" = 30'

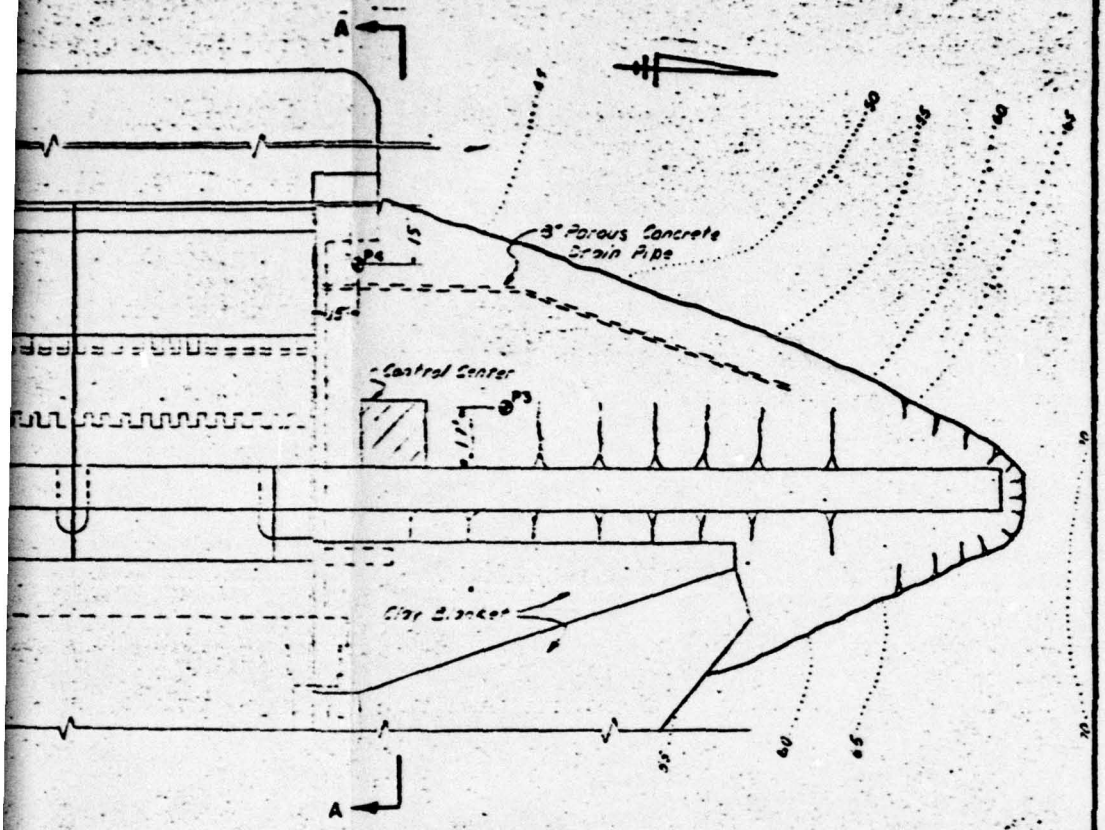


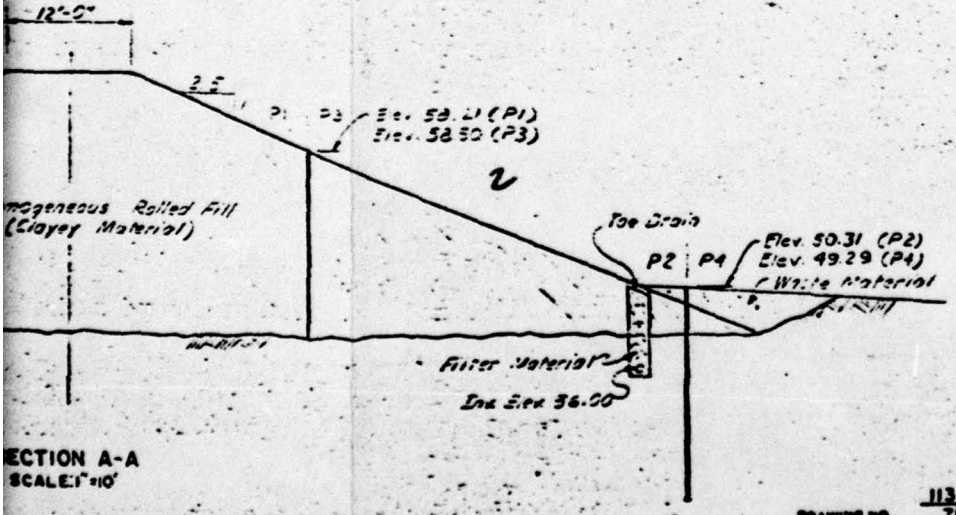
PIEZOMETER INSTALLATION
SCALE: 1 1/2" = 1'-0"



SECTION A-A
SCALE: 1" = 10'

PLATE 9





SECTION A-A
SCALE: 1" = 10'

DRAWING NO. 113-7 / 78 -2

HACKENSACK WATER CO.
WEEHAWKEN, N. J.

LAKE TAPPAN DAM
RIVERVALE-OLD TAPPAN, N.J.

PIEZOMETER STATIONS

SCALE: 1" = 30'-0" DATE: SEPT., 1978

DRAWN BY Y. H.	TRACED BY B. M.	CHECKED BY —	APPROVED BY

APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION
MAINTENANCE DATA

Check List
Visual Inspection
Phase 1

Name Dam Lake Tappan County Bergen State New Jersey Coordinators NJDEP

Date(s) Inspection Nov. 30, 1978 & Jan. 4, 1979 Weather Overcast Temperature 36°F

Coordinates: Lat. 41° 01' 05" N
Long. 74° 00' 01" W

Pool Elevation at Time of Inspection 44.8 ft M.S.L. Tailwater at Time of Inspection 35 ft. (approx.) M.S.L.

Inspection Personnel:

(Nov. 30, 1978)

J. A. Bischoff
R. C. Gaffin
D. J. Lachel
T. C. MacDonald

(Nov. 30, 1978)

F. L. Panuzio
A. R. Slaughter
P. L. Wagner
R.C. Gaffin Recorder

(Jan. 4, 1979)

R. J. Jenny
A. R. Slaughter

Owner Representatives

J. J. Cannizo
W. Grennan
B. Willis

CONCRETE/MASONRY DAMS

Lake Tappan Dam

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEEPAGE OR LEAKAGE	Minor seepage observed in gallery beneath gate bays as evidenced by lime deposits originating from cracks in walls and ceiling of gallery. These cracks coincide with cracks observed at 1/3 points of spillway crest and passing in upstream/	downstream direction. Water on floor of gallery was approx. 2" deep. Very minor seep observed on right abutment just several feet D.S. of dam (less than 1 gpm and clear) This seep could be runoff from recent rain.
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Contact between concrete structure and embankment appears good, with no visible offset or separation. Contact between embankments and foundation appears sound.	
DRAINS	One at south abutment. Appears to be in satisfactory condition.	Gallery was previously flooded to a depth of approximately 1 foot when drain was left open during high water.
WATER PASSAGES	See outlet works Popular road 300 ft. upstream on embankment with a 53 ft. by 22 ft. opening. Approximate road elevation 60 ft. MSL	
FOUNDATION	Appears sound	

CONCRETE/MASONRY DAMS

Lake Tappan Dam

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Cracks were observed at 1/3 points in each spillway bay and passing in U.S./D.S. direction. These cracks coincide with cracks observed in gallery beneath spillway bays. The cracks do not appear to have any structural significance. Minor cracking was observed on downstream	side of sill at 6' to 10' on center. Minor vertical cracks observed in right training wall. Several vert. & diag. cracks w/ minor leaching observed on left abutment retaining wall.
STRUCTURAL CRACKING	None observed. Dam appears structurally sound.	
VERTICAL AND HORIZONTAL ALIGNMENT	No vertical or horizontal offset or misalignment of gate bay deck observed.	
MONOLITH JOINTS	Not applicable	
CONSTRUCTION JOINTS	Minor offset - 1/8" max. as observed from gallery. Joints are basically tight. Only minor seepage at isolated locations was observed from the joints.	

EMBANKMENT

Lake Tappan Dam

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	No apparent movement or cracking at the toe could be observed	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Minor unevenness of downstream slopes observed. Both embankments appear to be in generally good condition.	
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	No apparent settlement or horizontal movement of crest of either embankment observed.	
RIPRAP FAILURES	None observed	

EMBANKMENT

Lake Tappan Dam

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VEGETATION	Both embankment sections covered with grass and several "landscape" trees located on the upstream side of the embankment crests. These trees do not appear to threaten the stability of the dam due to their location on the top of the embankments and small size.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Contact of both embankment sections with abutments and concrete spillway structure appear to be tight and undisturbed.	
ANY NOTICEABLE SEEPAGE	Minor seep (less than 1 gpm and flowing clear) was observed approximately 10 feet downstream of right embankment. No seepage could be observed from either embankment.	It is possible that this seepage was a result of recent rains, exiting at embankment toe drain. Source of this seep should be confirmed.
STAFF GAGE AND RECORDER	Staff gage was observed on upstream end of right training wall. Stage is recorded by electric gage.	
DRAINS	Weep hole drains are present at downstream sides of training walls. No seepage noted during inspection.	

OUTLET WORKS

Lake Tappan Dam

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Outlet works submerged and discharging at time of inspection. Control valve on crest of dam near upstream side of dam near upstream side of dam (right end of spillway structure) well maintained and operating.	
INTAKE STRUCTURE	Intake structure submerged at time of inspection. No observations could be made.	
OUTLET STRUCTURE	Outlet through concrete structure was submerged and discharging at time of inspection. No observations could be made.	
OUTLET CHANNEL	A section of the sill at the downstream edge of the concrete aproh has been removed to allow unrestricted passage of water from outlet to downstream channel.	
EMERGENCY GATE	Sluice gate submerged during inspection and therefore could not be observed.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Not applicable	
APPROACH CHANNEL	Not applicable	
DISCHARGE CHANNEL	Not applicable	
BRIDGE AND PIERS	Not applicable	

GATED SPILLWAY

Lake Tappan Dam

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Transverse cracks at 1/3 points across each of the four gate bays. Do not appear to be recent and are of no apparent structural significance.	
APPROACH CHANNEL	Channel and adjacent embankments are lined with clay. Clay blanket was submerged and could not be closely inspected, but appears to be in satisfactory condition.	
DISCHARGE CHANNEL	Discharge channel lined with riprap downstream of concrete apron. No erosion could be observed immediately downstream of apron. Portion of end sill at right end, in line with discharge outlet, was not constructed.	
BRIDGE AND PIERS	Concrete piers between each spillway bay appear to be in good condition with only minor surface spalling. Minor spalls were observed at top of piers at junction with spillway bridge deck.	
GATES AND OPERATION EQUIPMENT	Gates and automatic hoist equipment are in excellent condition and well maintained. Water tightness of seals could not be determined because reservoir stage was below level of the gates. Gates are operated manually twice a year. Hoist equipment chambers in each pier are well maintained, concrete surfaces are dry.	

INSTRUMENTATION

Lake Tappan Dam

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	Four piezometers, 2 on each embankment. Section of P.V.C. above ground is broken off of piezometer on upper left embankment.	
OTHER	Staff-gage located on upstream end of right wingwall.	

RESERVOIR

Lake Tappan Dam

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Slopes appear stable and gently sloping.	
SEDIMENTATION	None apparent. No evidence of sedimentation found.	
PURPOSE	Water supply. During spillway discharge, reservoir water level is maintained at elevation 55 M.S.L.	
DEBRIS	Only very minor debris observed. Minimal debris build-up reported during floods. Occasional build-up of ice.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Channel is well defined but relatively shallow being of wide base trapezoidal cross section. High debris potential. Flood plain is heavily wooded.	
SLOPES	Much of downstream flood plain is swamp. Gentle slopes.	
APPROXIMATE NO. OF HOMES AND POPULATION	None visible from dam. Boroughs of Old Tappan (population 4000) and Rivervale and medium duty roads are located approximately 1/2 to 3/4 miles downstream.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Lake Tappan Dam

ITEM	REMARKS
PLAN OF DAM	Plan and sections of dam and appurtenances are shown on as-built drawings prepared by Buck, Seifert and Jost Consulting Engineers, Englewood Cliffs, New Jersey and John S. Cotton, Consulting Engineer, Kentfield, Calif., 32 sheets.
REGIONAL VICINITY MAP	Locality plan presented on cover sheet of as-built drawings.
CONSTRUCTION HISTORY	Invitation to bidders, instructions to bidders, specifications, proposal contract and bond; for the construction of New Jersey Dam No. 3, dated February, 1965, prepared by Buck, Seifert and Jost. Monthly construction progress reports were specified.
TYPICAL SECTIONS OF DAM	See "Plan of Dam"
HYDROLOGIC/HYDRAULIC DATA	a. Hydrographs of the following storms: Sept. 12/13, 1971; July 13, 1972; Feb. 1, 2, & 3, 1973, and Sept. 24 to 28, 1975. b. Spillway discharge curve for four 6' x 50' gates and tailwater curve. c. Stage/capacity curve for reservoir, Dwg. 154-1 p Rev. 1 73 d. Phase I Inspection Report for Lake Forest Dam 1, including hydrologic/ hydraulic data, dated 14 January 1978.
OUTLETS - PLAN	See "Plan of Dam"
- DETAILS	
-CONSTRAINTS -DISCHARGE RATINGS	Chart showing Sluice Gate Discharge vs Number of Turns Open dated April, 1967.
RAINFALL/RESERVOIR RECORDS	No rainfall records. See "Maintenance/Operation Records" regarding reservoir records.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Lake Tappan Dam

ITEM	REMARKS
DESIGN REPORTS	None available
GEOLOGY REPORTS	None available
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	See 'Hydrologic/Hydraulic Data a) Stability analyses prepared for concrete gravity section of dam pp. B-5 through B-8, no date. b) Dam foundation pressures presented on as-built drawing No. 400-27-13, dated October, 1964. Computations not shown. No seepage analyses available. Dam foundation Pressures reportedly includes effect of uplift, determined from flow nets.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Boring logs presented on as-built drawing No. 400-27-14, dated October, 1964. Specifications were given for the moisture content and degree of compaction of the embankment soil; however, no inspection or test results are available.
POST-CONSTRUCTION SURVEYS OF DAM	None
BORROW SOURCES	Embankment material obtained from Borrow Pits No. 3 and 4 in the reservoir.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

• Lake Tappan Dam

ITEM	REMARKS
SPILLWAY-PLAN -SECTIONS -DETAILS	See "Plan of Dam"
OPERATING EQUIPMENT PLANS & DETAILS	See "Plan of Dam"
MONITORING SYSTEMS	(None at present) A program is about to be initiated for monthly readings of piezometers. Piezometers shown on Dwg. No. 113-7 / 78 - 2 dated September, 1978.
MODIFICATIONS	Flow splitters were installed at the top of the gates to change the harmonics of the flow so as to reduce downstream disturbance. Mechanical stops were installed on the bascule gates to ensure that jamming of the gates would not occur during a flood.
HIGH POOL RECORDS	See 'Hydrologic/Hydraulic Data"
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Lake Tappan Dam

ITEM	REMARKS
MAINTENANCE OPERATION RECORDS	Reservoir and gate angle records are available for the following storms: June 18 to 20, 1972; February 1 to 4, 1973; September 25 to 28, 1975; and November 7 to 10, 1977..

APPENDIX B

PHOTOGRAPHS

(Note: All photographs were taken on Nov. 30, 1978)

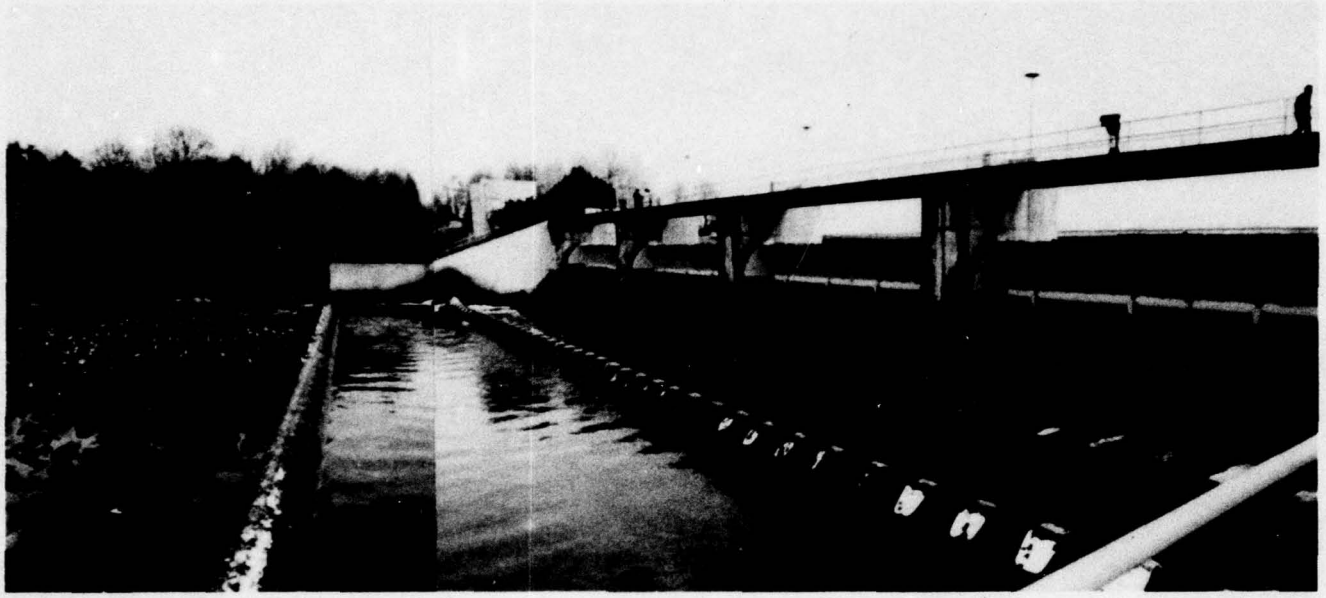


Photo 1 View of the Downstream Face of Spillway

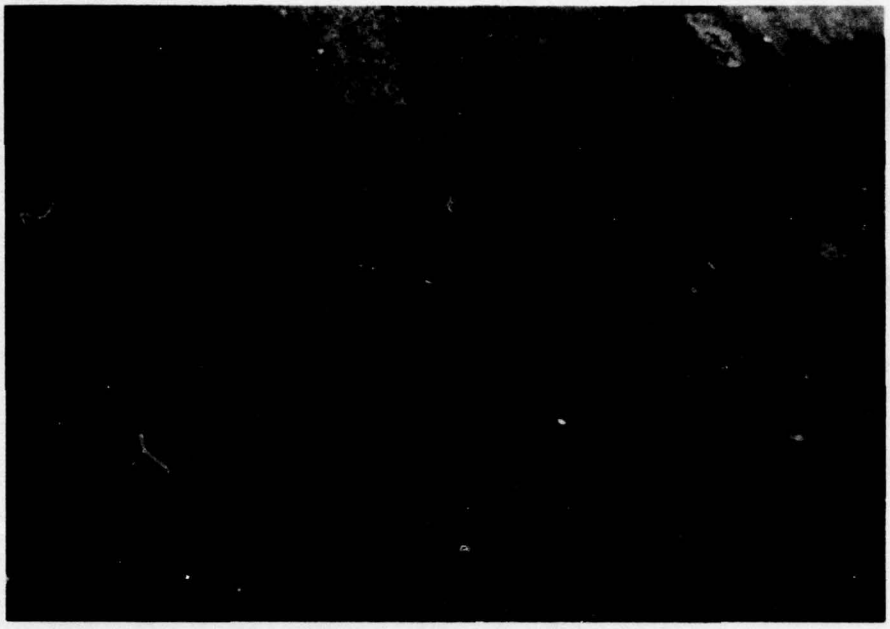


Photo 2 View of Crack in Spillway Crest.

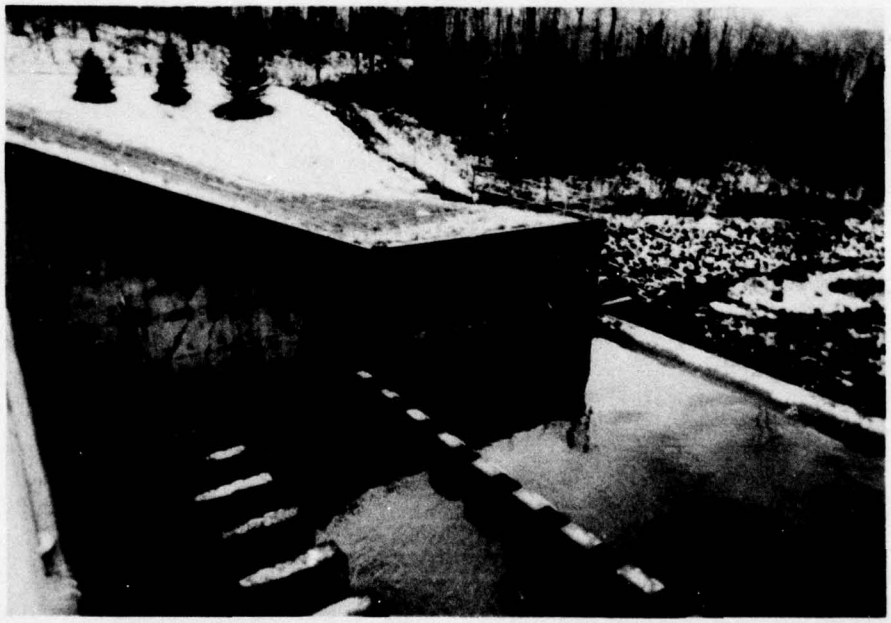


Photo 3 View of Downstream Section of Left Training Wall.

Photo 4 View of Bridge Deck and South Bank of Approach Channel.

Photo 5 View of Left Embankment Looking Upstream Showing Top of Piezometer P-2 (Arrow).

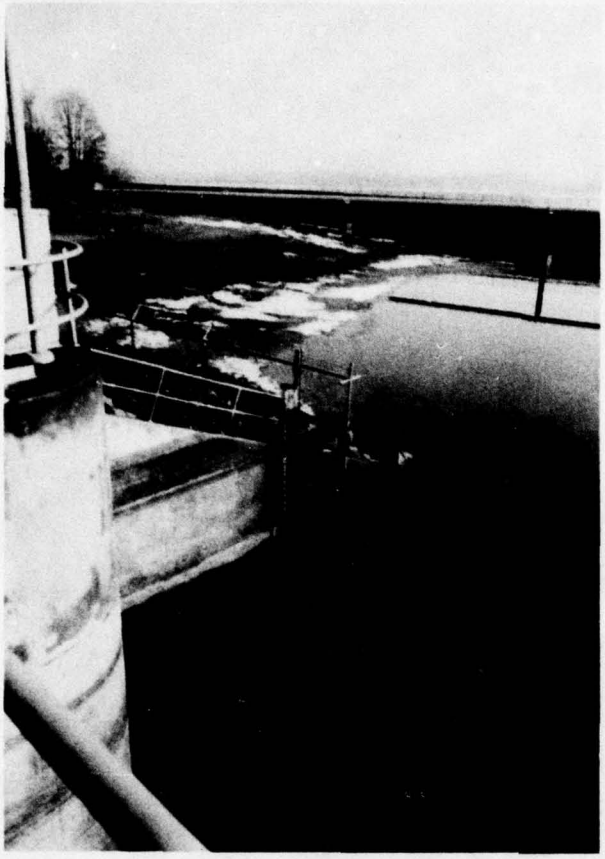


Photo 6 View of Upstream End of Right Training Wall Showing Staff Gages.

Photo 7 View of Seep (Arrow) Downstream of Right Embankment.

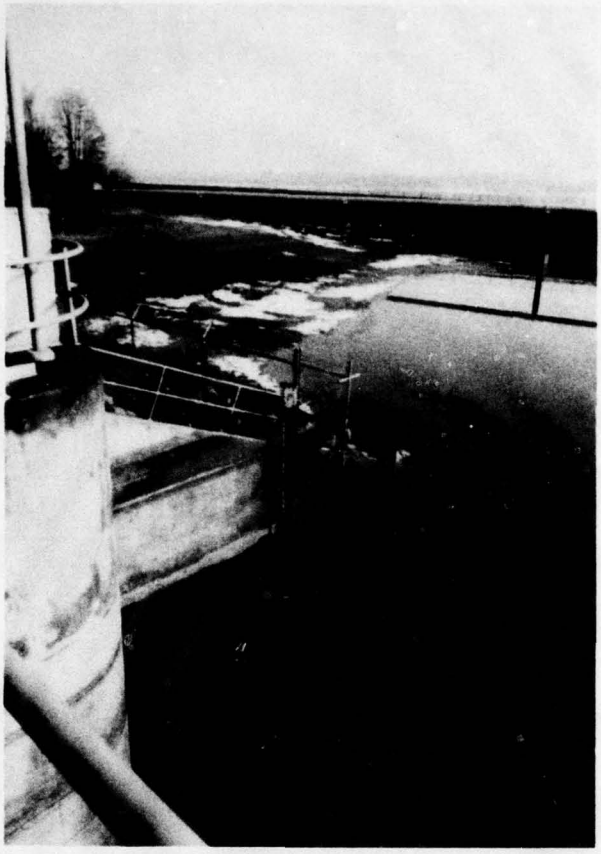


Photo 6 View of Upstream End of Right Training Wall Showing Staff Gages.

Photo 7 View of Seep (Arrow) Downstream of Right Embankment.

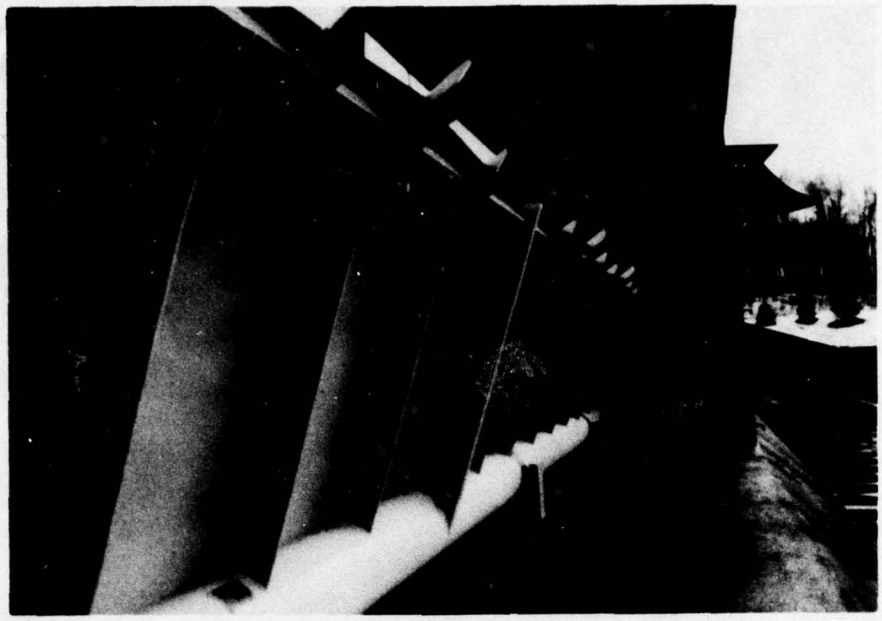


Photo 8 View of Downstream Side of Bascule Gate No. 1 Looking South. Arrow indicates Spalling at Top of Pier.

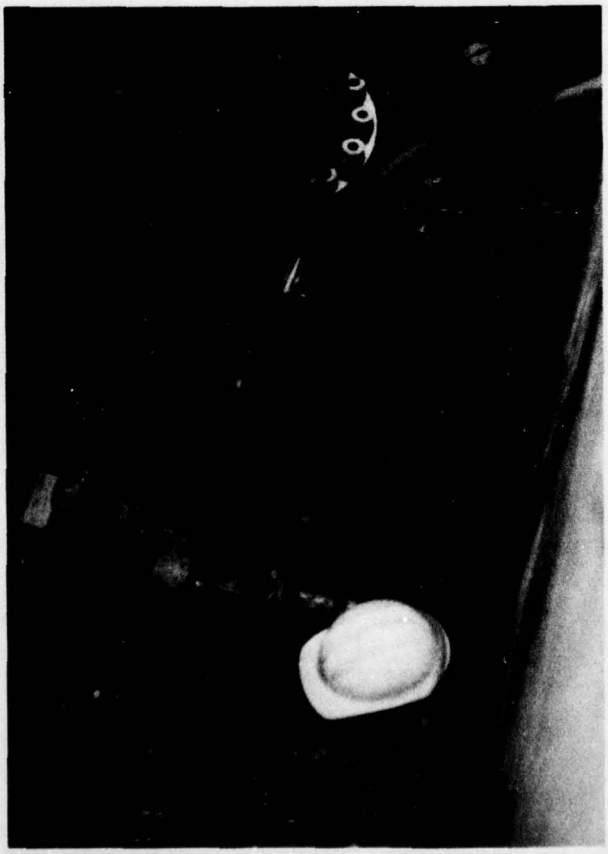


Photo 9 View Looking Down Into Pier No. 1 Showing Gate Operating Cylinder.

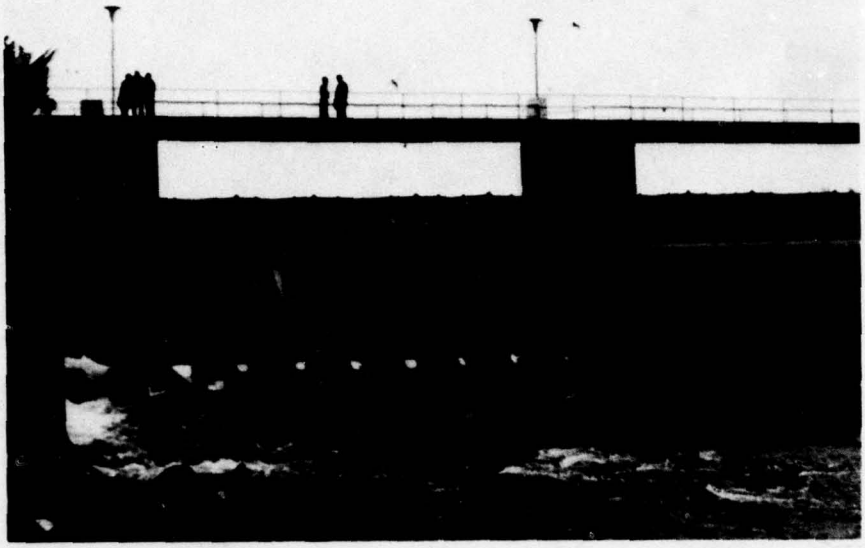


Photo 10 View of North End of Spillway Looking Upstream Showing Outlet Channel.

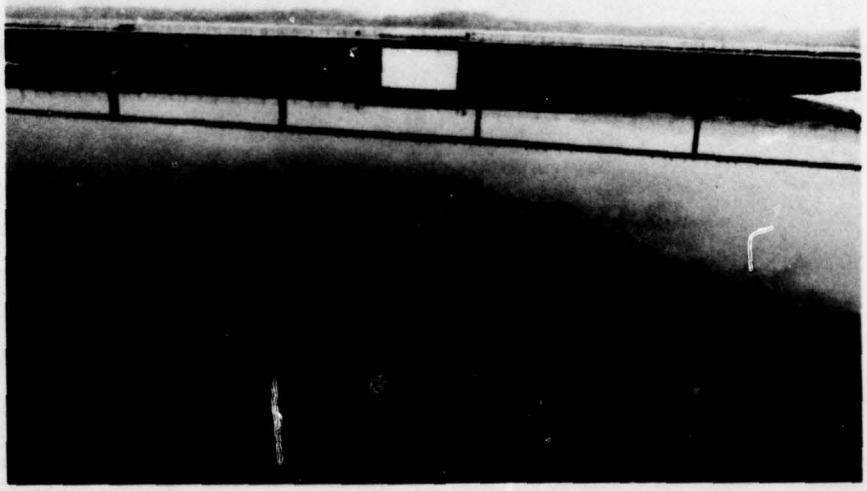


Photo 11 View Looking Upstream From Dam Crest.

Photo 12 View Looking Downstream From Dam Crest.

APPENDIX C

REGIONAL GEOLOGY - PIEDMONT LOWLANDS

REGIONAL GEOLOGY - PIEDMONT LOWLANDS

Physiography

The Piedmont Lowlands Province of New Jersey lies northwest of a line approximately between Trenton and Perth Amboy and southeast of an approximate line between Milford on the Delaware River and Mahwah near the New York State border. Physiographically, the province is situated between the predominantly Precambrian age New Jersey Highlands Province to the northwest and the typically unconsolidated Creataceous age and younger sediments of the Coastal Plain Province to the southeast. (See Figure C-1).

Bedrock

The Piedmont Lowlands, encompassing about one-fifth of the state, is characterized by northwestward dipping bedrock composed of interbedded red shales, siltstones and sandstones of Triassic and Jurassic age and igneous basalt extrusions (lava flows) and diabase intrusions of Jurassic age. The sedimentary rocks have been eroded to a broad southeastward sloping piedmont plain. The northwest border of the province is a northeast-southwest trending fault zone (Ramapo Fault) which truncates the sedimentary beds. Total vertical displacement on the fault may reach 10,000 feet.

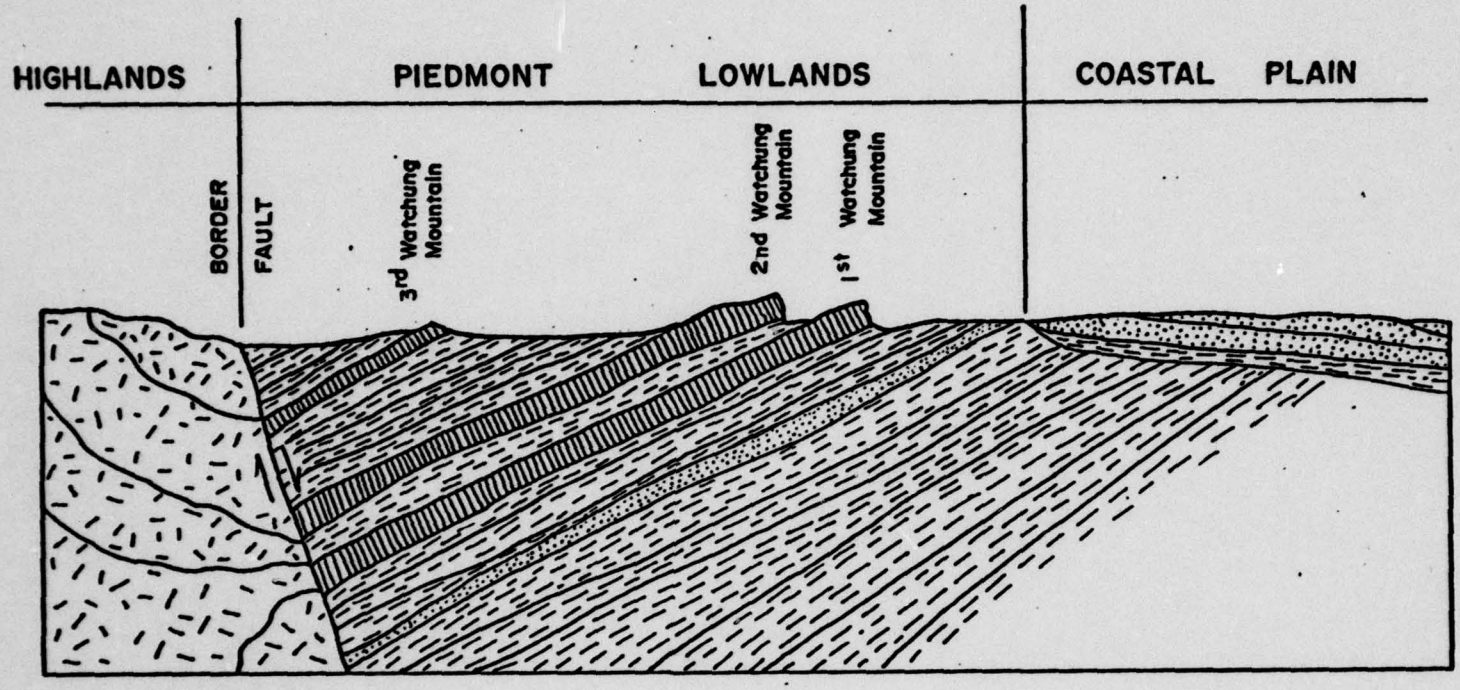
The gently rolling lowland topography of the piedmont lowlands is pierced by long asymetric ridges of hard

and resistant igneous rocks which were intruded into or on top of the sedimentary sequences. With the subsequent erosion of the softer sedimentary rocks, these igneous formations have been left standing, often in bold relief, up to 400 ft. above the surrounding plains. The igneous bodies composed of diabase and basalt form the Palisades along the Hudson River and the three Watchung Mountain ridges of the central Piedmont. The ridges are all steeper on the southeast with gentle dip slopes to the northwest.

Overburden

The Pleistocene Age Wisconsin continental glacier has smoothed and filled approximately the northern half of the province. The terminal moraine of the glacier extends from Perth Amboy to Summit then northwestward to Morris Plains. North of the morainal line the soils characteristically consist of glacial tills overlying the bedrock with scattered overlying stratified outwash deposits. At least three large glacial lakes occupied portions of the area north of the moraine at different periods, resulting in a relatively flat topography composed predominantly of silts and clays.

South of the terminal moraine, most of the overburden consists of alluvial deposits overlying a more highly developed weathered transition zone on top of the bedrock. Some highly weathered tills of pre-Wisconsin glaciation can be found on the top of intervalley ridges. Much of the alluvium is glacial outwash.



Pre-cambrian gneisses, schists and metasediments

Triassic and Jurassic shales, sandstones & siltstones

Lava (Basalt) flows

Cretaceous and younger age unconsolidated deposits

SCHEMATIC CROSS-SECTION OF
NEW JERSEY PIEDMONT LOWLANDS
PHYSIOGRAPHIC PROVINCE

JENNY / LEEDSHILL
JANUARY 1979

FIGURE C-1

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 49.4 sq. mi

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 55 Ft (10650 AF)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N/A

ELEVATION MAXIMUM DESIGN POOL:

ELEVATION TOP DAM: 64 ft.

CREST: SPILLWAY

a. Elevation 49'
b. Type OGEE
c. Width —
d. Length 4x50'
e. Location Spillover CENTER OF DAM
f. Number and Type of Gates 4 - 6' x 50' BASCULE GATES

OUTLET WORKS:

a. Type 54"x48" BOX
b. Location LEFT END OF SPILLWAY (LOOK DOWNSTREAM)
c. Entrance inverts 37 FT
d. Exit inverts
e. Emergency draindown facilities

HYDROMETEOROLOGICAL GAGES: USGS 01377000
a. Type USGS GAGING STA / STAFF GAGE
b. Location USGS IN BINGHAMTON / UPSTREAM SIDE OF DAM
c. Records

MAXIMUM NON-DAMAGING DISCHARGE: 45000 CFS (Top of dam)

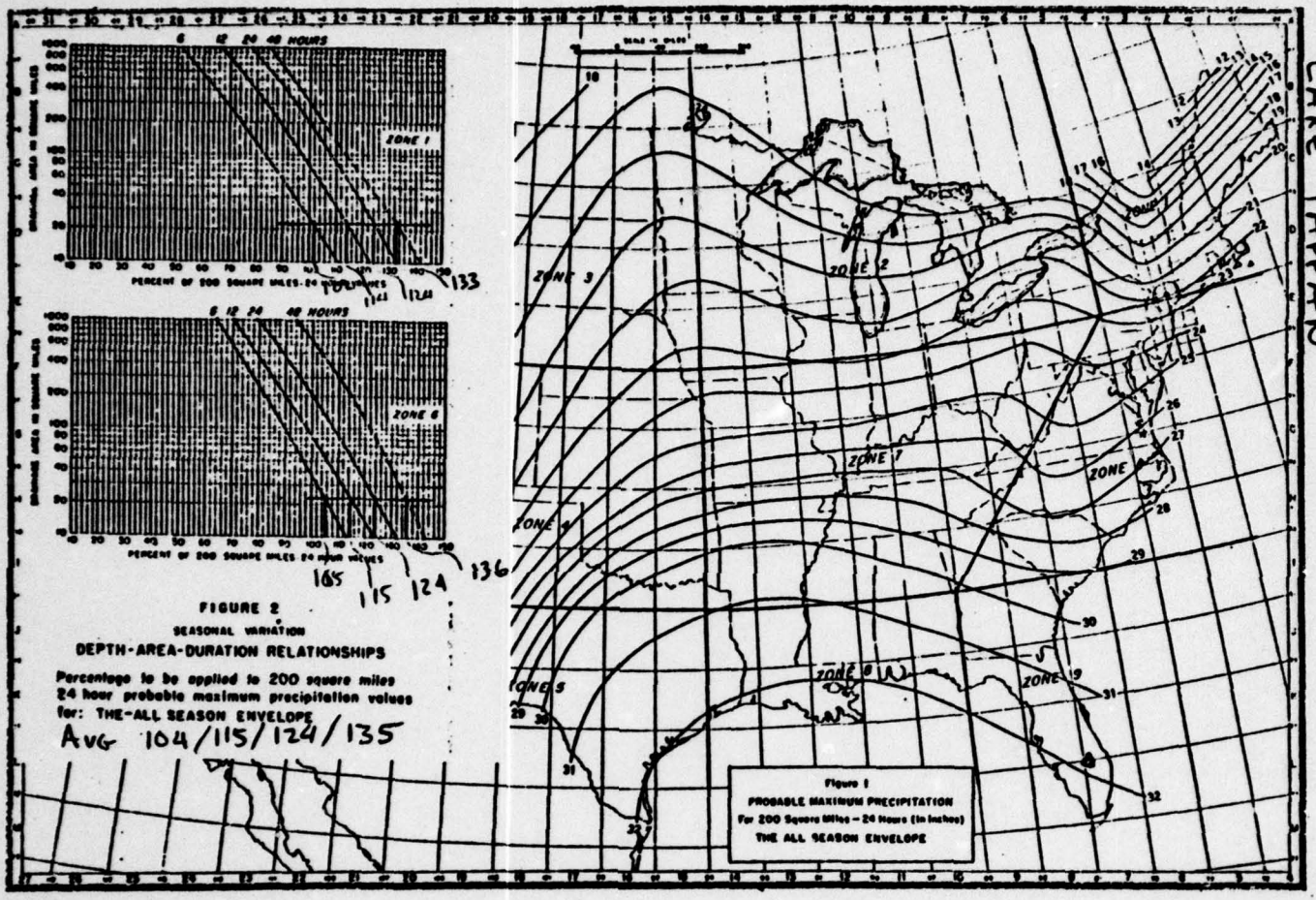


FIGURE 2

SEASONAL VARIATION

DEPTH-AREA-DURATION RELATIONSHIPS

Percentage to be applied to 200 square miles 24 hour probable maximum precipitation values for: THE ALL SEASON ENVELOPE

AVG 104/115/124/135

Figure 1

PROBABLE MAXIMUM PRECIPITATION

For 200 Square Miles — 24 Hours (In Inches)

THE ALL SEASON ENVELOPE

D-2

TR 71 0215

LEEDS, HILL AND JEWETT, INC.

BY LBE DATE 790122 CLIENT N.J. SHEET NO. OF

CHKD. DATE JOB LAKE TAPPAN JOB NO. 302-03

j. For Lake Tappan (NJ 00246) use the outflow hydrograph from the Deforest Dam (copy of report forwarded under separate cover) and add the local inflow from the intermediate drainage area. Use the following equation to develop the Clark coefficients for the intermediate area.

$$t_c = 8.29(1.0 + 0.03\ I)^{-1.28} \left(\frac{DA}{S}\right)^{0.28}$$

$$\frac{R}{t_c + R} = 0.65$$

where

D.A = drainage area in square miles = 22.8 (EXCLUDING DEFOREST)

S = watercourse slope, in feet per mile, defined as the average slope of the watercourse between points 10 and 85 percent of the distance upstream from the runoff site to the watershed boundary = 140-48 / (9.6 mi - 1.3 mi) = 10.9 FT/MI

I = index of impervious cover in percent of total land area = 25% (LHT ESTIMATE FROM USGS)

t_c = time in hours from the end of a burst of rainfall excess to the inflection point on the recession limb of the resulting direct runoff hydrograph (Clark Method)

R = discharge at the inflection point on the recession limb of the direct runoff hydrograph divided by the slope of the recession limb at that point, in hours (Clark Method).

$$t_c = 8.29(1.0 + 0.03\ (25))^{-1.28} \left(\frac{22.8}{10.9}\right)^{0.28}$$

$t_c = 4.96$ hrs

$$\frac{R}{4.96 + R} = 0.65$$

$R = 9.21$ hrs

LAKE TAPPAN

RBE 740207 307-03

LOCATION MAP OF CROSS-SECTIONS USED IN ROUTING

LEEDS, HILL AND JEWETT, INC.

BY RBE DATE 790123 CLIENT New Jersey SHEET NO. ___ OF ___

CHKD. ___ DATE ___ JOB ___ JOB NO. 202-01

LAKE TAPPAN

Channel Cross-Sections

	Station	Distance Downstream of Dam (ft)	Manning's n Left Over-Bank	Manning's n Main Channel	Manning's n Right Over-Bank	Channel Invert (ft)	Max Elev. (ft)	Reach Length (ft)	Energy Grade Line Slope	X or Y	X or Y (ft) 1	2	3	4	5	6	7	8
6	1-Below Deforest	4000	0.10	.045	0.10	57	80	4000	.0003	X	6	200	375	375	475	425	950	1600
										Y	80	70	60	57	57	59	60	80
	2	19000	0.10	.045	0.10	52	80	15000	.0003	X	0	300	1375	1375	1425	1425	1450	16000
										Y	80	60	54	52	52	54	60	80
5	3	28800	0.10	.045	0.10	50	80	9800	.0002	X	0	300	475	475	525	525	875	1150
										Y	80	60	53	50	50	53	60	80
	Below Tappan																	
	7	500	0.10	0.045	.10	34	70	500	.0006	X	0	200	225	225	275	275	325	500
										Y	70	40	31	34	34	37	40	70
	8	3600	0.10	.045	.10	32	60	3100	.0006	X	0	100	825	825	875	875	1100	1200
										Y	80	50	35	32	32	35	40	60
	9	10100	0.10	.045	.10	28	50	6500	.0006	X	0	500	700	750	800	850	1300	1550
										Y	50	40	30	28	28	30	40	50

AD-A069 220 NEW JERSEY STATE DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/G 13/2
NATIONAL DAM SAFETY PROGRAM. LAKE TAPPAN DAM (NJ 00246). HACKEN--ETC(U)
MAY 79 R J JENNY DACW61-78-C-0124

UNCLASSIFIED NL

2 OF 2
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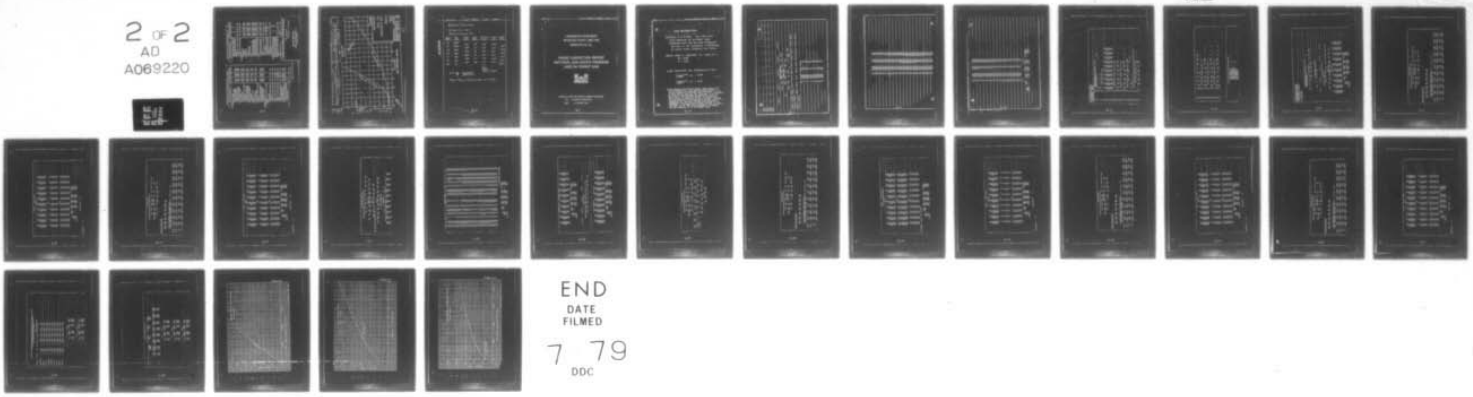

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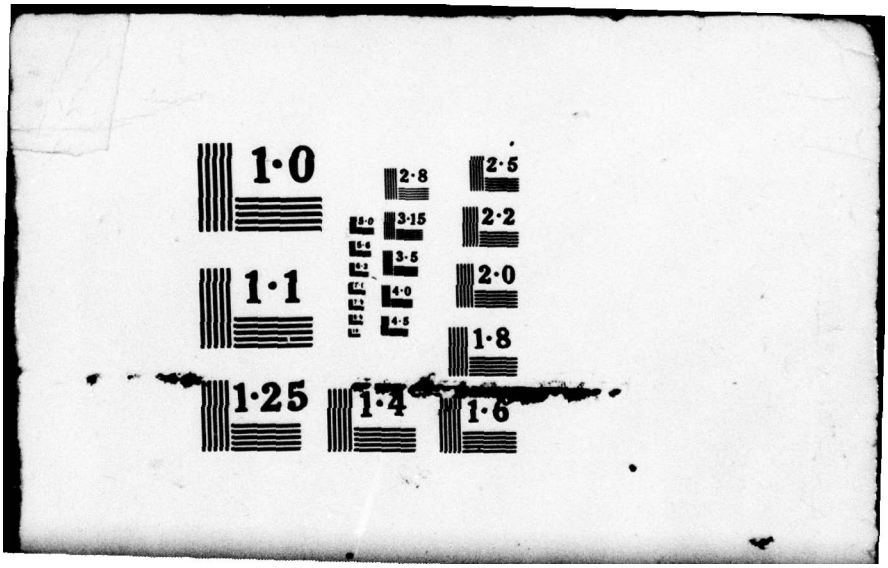

1·0
1·1
1·25
2·8
3·15
3·5
4·0
4·5
1·4
2·5
2·2
2·0
1·8
1·6

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n (continued)

Type of channel and description	Minimum	Normal	Maximum
C. EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
D. NATURAL STREAMS			
D-1. Minor streams (top width at flood stage <100 ft)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

MAIN CHANNEL
STATIONS 1,2,3,5,6,7

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n (continued)

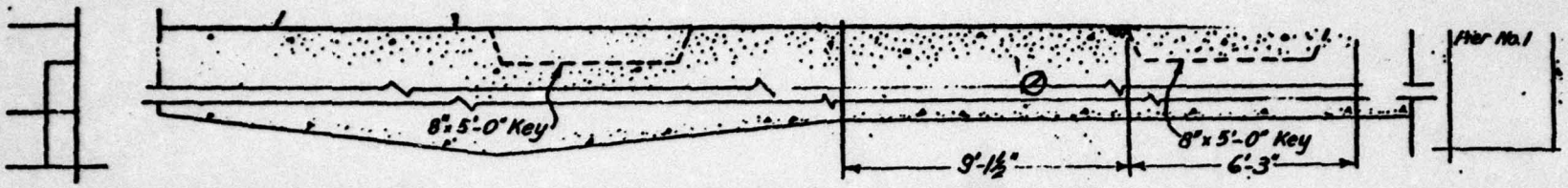
Type of channel and description	Minimum	Normal	Maximum
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
D-2. Flood plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
D-3. Major streams (top width at flood stage >100 ft). The n value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	.....	0.060
b. Irregular and rough section	0.035	.....	0.100

OVERBANK
STATIONS 1,2,3,5,6,7

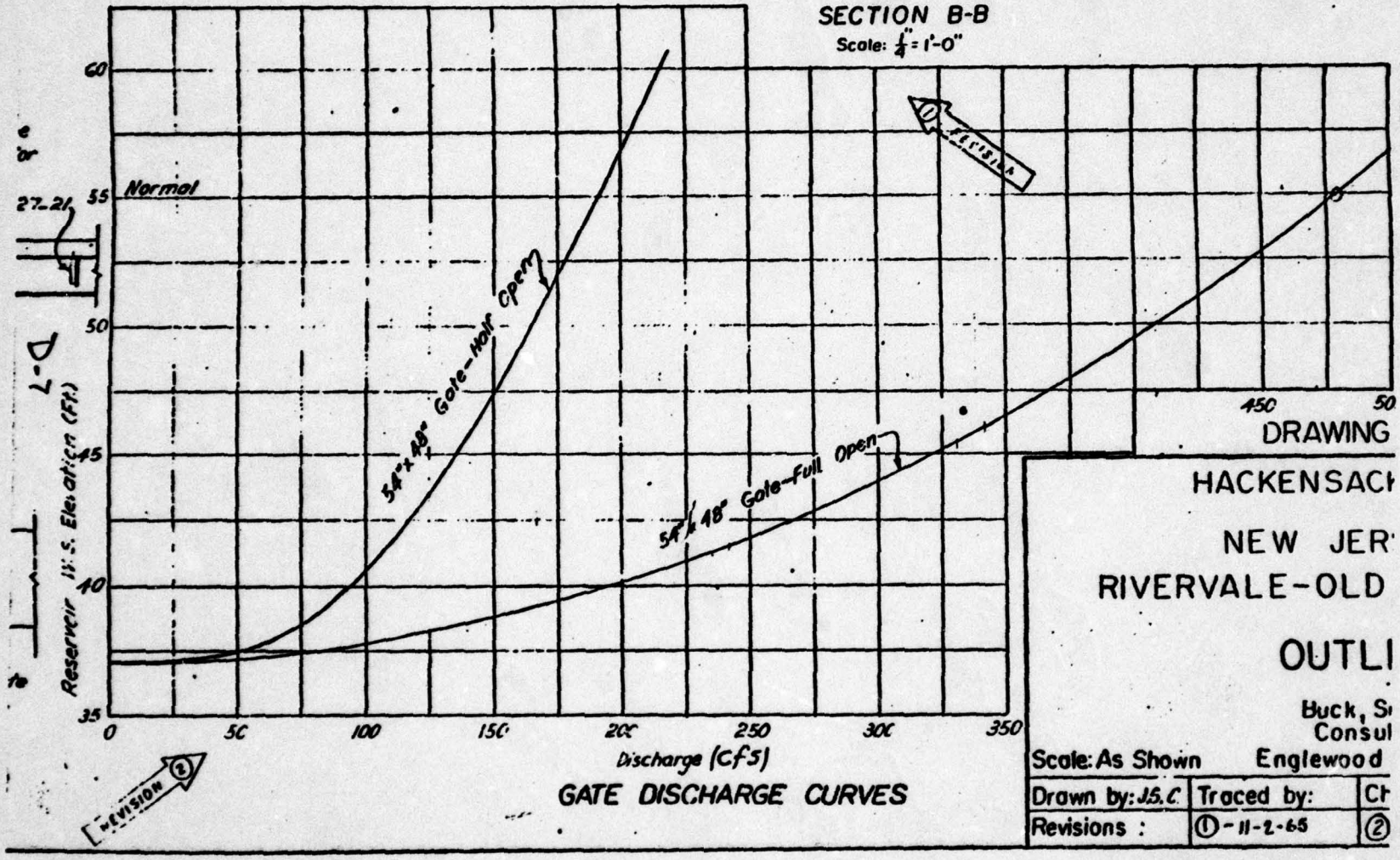
OPEN-CHANNEL HYDRAULICS

VEN TE CHOW, Ph.D.

Professor of Hydraulic Engineering
University of Illinois



SECTION B-B
Scale: ¼"=1'-0"



GATE DISCHARGE CURVES

DRAWING

HACKENSACK

NEW JER

RIVERVALE-OLD

OUTLI

Buck, S
Consul

Scale: As Shown Englewood

Drawn by: J.S.C.	Traced by:	Ch
Revisions :	① - 11-2-65	②

302-03	LAKE TAPPAN	RBE 790201

DRAWDOWN CALCULATION

TOP SPWY EL = 49 FT

BOTTOM OF OUTLET = 37

ELEV. (FT)	STO (AF)	ΔSTO (AF)	MEAN ELEV.	DISCHARGE CFS	ΔTIME hr	ΣTIME hr
49	5250					
		1450	48	375	46.8	
47	3800					46.8
		1500	46	340	53.4	
45	2300					100.2
		800	44	300	32.3	
43	1500					132.5
		800	42	240	40.3	
41	700					172.8
		400	40	195	24.8	
39	300					197.6
		260	38	110	28.6	
37	40					226.2

↑ FROM RATING CURVE IN PLANS

$$\Delta T = \frac{\Delta S}{Q} \quad \frac{43560 \text{ FT}^3/\text{AF}}{3600 \text{ SEC/HR}}$$

TOTAL TIME = 226.2 hr / 24 = 9.4 DAYS

HACKENSACK RIVER BASIN

ROCKLAND COUNTY, NEW YORK

INVENTORY NO. 95

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LAKE DE FOREST DAM

Prepared by: NEW YORK DISTRICT CORPS OF ENGINEERS

For: THE STATE OF NEW YORK

Date: 14 JANUARY 1978

D-9

LAKE DE FOREST DAM

HACKENSACK R. AT W. NYACK D.A. = 29.4 SQ.MI.

- FLOW REGULATED BY DE FOREST LAKE.
- DISCHARGE GIVEN FOR THIS GAGE REPRESENTS THE FLOW OF THE HACKENSACK R. DOWNSTREAM OF WATER SUPPLY DIVERSION FOR NYACK.

PASCACK BROOK AT WESTWOOD. D.A. = 29.6 SQ. MI.

$T_c = 14.83$

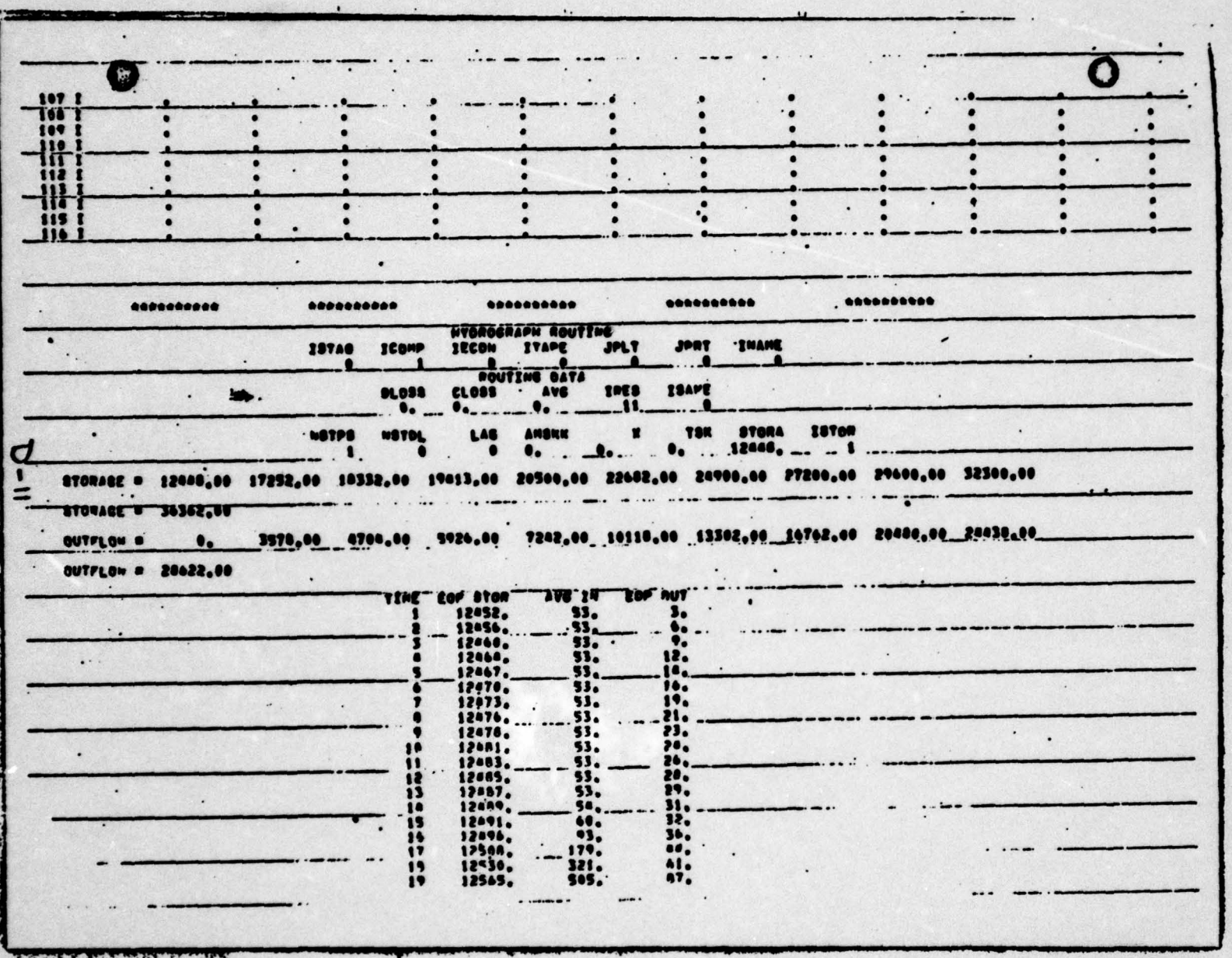
$R = 6.88$

CLARK PARAMETERS FOR HACKENSACK R. AT DAM:

$$\left(\frac{26.6}{29.6}\right)^{0.25} \times T_c = 14.43$$

$$\left(\frac{26.6}{29.6}\right)^{0.25} \times R = 6.70$$

* GAGE RECORDS FROM PASCACK BROOK WERE RELIABLE. THE UNIT HYDROGRAPH WAS WELL DEFINED. OPTIMIZATION OF THE UNIT HYDROGRAPH PARAMETERS (CLARK'S) YIELDED $T_c = 14.83$ $R = 6.88$. RECORDS FROM THE WEST NYACK GAGE (1 MILE DOWNSTREAM OF DE FOREST LAKE DAM) WERE NOT REPRESENTATIVE OF THE BASIN DUE TO THE REGULATING EFFECT OF THE RESERVOIR AND DIVERSION. INVESTIGATION OF THE TWO BASINS (PASCACK BR. AND HACKENSACK R. AT DAM) REVEALED PHYSICAL SIMILARITY. THEREFORE THE HYDROLOGIC FEATURES WERE CONSIDERED PROPORTIONATE FOR THE SAME SIZE BASIN. BECAUSE OF THE DIFFERENCE IN DRAINAGE AREA, A RATIO OF THE TWO BASINS WAS USED TO FIX THE UNIT HYDROGRAPH PARAMETERS FOR THE HACKENSACK R. AT DE FOREST LAKE.



HYDROGRAPH ROUTING

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
0	1	0	0	0	0	0

ROUTING DATA

RLOSS	CLOSS	AVG	IRES	ISAPE
0.	0.	0.	11	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISTOR
1	0	0	0.	0.	0.	12448.	1

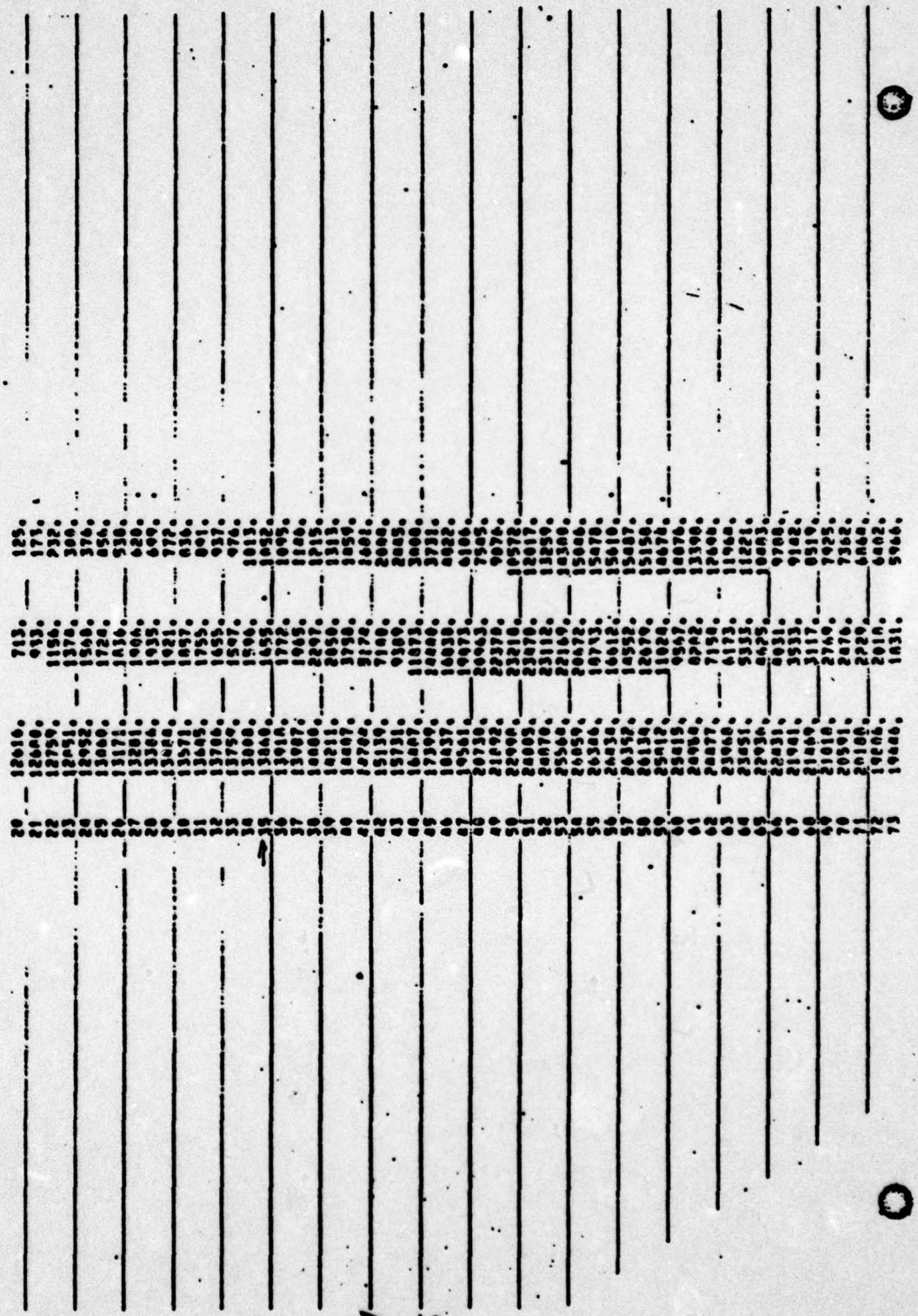
STORAGE = 12448.00 17252.00 18332.00 19813.00 20500.00 22602.00 24900.00 27200.00 29600.00 32300.00

STORAGE = 36362.00

OUTFLOW = 0. 3578.00 4704.00 5926.00 7242.00 10110.00 13302.00 16762.00 20480.00 24438.00

OUTFLOW = 28622.00

TIME	EOP STOR	AVG IN	EOP OUT
1	12452.	53.	3.
2	12456.	53.	6.
3	12460.	53.	9.
4	12464.	53.	12.
5	12467.	53.	16.
6	12470.	53.	16.
7	12473.	53.	19.
8	12476.	53.	21.
9	12478.	53.	23.
10	12481.	53.	26.
11	12483.	53.	26.
12	12485.	53.	28.
13	12487.	53.	29.
14	12489.	54.	31.
15	12491.	60.	32.
16	12496.	93.	36.
17	12508.	179.	46.
18	12536.	321.	61.
19	12585.	505.	87.



74	19107.	1668.	5580.
75	18785.	1510.	5217.
76	18481.	1345.	4873.
77	18193.	1226.	4559.
78	17918.	1088.	4272.
79	17655.	958.	3998.
80	17408.	828.	3736.
81	17163.	715.	3512.
82	16931.	612.	3339.
83	16708.	516.	3170.
84	16488.	427.	3006.
85	16269.	326.	2846.
86	16060.	240.	2691.
87	15860.	191.	2541.
88	15669.	161.	2399.
89	15489.	145.	2265.
90	15317.	130.	2137.
91	15155.	118.	2016.
92	15002.	107.	1902.
93	14858.	98.	1795.
94	14721.	91.	1693.
95	14592.	86.	1597.
96	14471.	81.	1506.
97	14358.	77.	1421.
98	14248.	74.	1341.
99	14144.	71.	1265.
100	14050.	69.	1193.
101	13960.	66.	1126.
102	13875.	65.	1063.
103	13795.	63.	1003.
104	13719.	62.	947.
105	13648.	61.	894.
106	13581.	60.	844.
107	13518.	59.	797.
108	13459.	58.	753.
109	13403.	56.	711.
110	13350.	54.	672.
111	13301.	53.	635.
112	13254.	53.	600.
113	13210.	53.	568.
114	13169.	53.	537.
115	13130.	53.	508.
116	13094.	53.	481.
SUM			422575.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	15610.	15242.	11736.	5654.	422575.
INCHES		5.33	16.42	23.73	20.63
AC-FT		7962.	23290.	33662.	30982.

D-13

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*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  25 SEP 78
*********************************
    1         A1      NEW JERSEY DAM SAFETY - LAKE TAPPAN I.D. NO. 00246
    2         A2      HYDRAULIC-HYDROLOGIC ANALYSIS   302-03
    3         A3      PROBABLE MAXIMUM FLOOD                          -RBE-
    4         B    110      1      0      0      0      0      0      0      0      0
    5         B1     5
    6         J      1      4      1
    7         J1  0.25    0.5   0.75    1.0
    8         K      0      1                                  1
    9         K1        OUTFLOWS FROM DEFOREST LAKE
   10         M     -1           26.6          26.6
   11         Q      3      6      9     12     14     16     19     21     23     24
   12         Q     26     28     29     31     32     36     44     61     87    125
   13         Q    173    232    300    376    456    538    620    699    772    836
   14         Q    891    937    976   1013   1052   1095   1146   1215   1313   1459
   15         Q   1601   2004   2445   3000   3731   4822   6106   7545   9076  10572
   16         Q  12017  13259  14300  15046  15479  15610  15407  15158  14674  14076
   17         Q  13396  12674  11764  11221  10403   9700   9142   8519   7925   7362
   18         Q   6964   5402   5965   5580   5217   4873   4559   4272   3998   3736
   19         Q   3512   3339   3170   3006   2846   2691   2541   2399   2265   2137
   20         Q   2016   1902   1795   1693   1597   1506   1421   1341   1265   1193
   21         Q   1123   1063   1003    947    894    844    797    753    711    672
   22         K      1      2                                  1
   23         K1     ROUTING OUTFLOW TO STATION 2 / ABOVE LAKE TAPPAN
   24         Y                           1      1
   25         Y1     1                                        -1
   26         Y6  0.10  0.045   0.10     57     80   4000 0.0003
   27         Y7     0     80    200     70    375     60    375     57    425     57
   28         Y7   425     59    950     60   1600     80
   29         K      1      3                                  1
   30         K1     ROUTING OUTFLOW TO STATION 3 / ABOVE LAKE TAPPAN
   31         Y                           1      1
   32         Y1     1                                        -1
   33         Y6  0.10  0.045   0.10     52     80  15000 0.0003
   34         Y7     0     80    300     60   1375     54   1375     52   1425     52
   35         Y7  1425     54   1450     60   1600     80
   36         K      0      4                                  1
   37         K1     RUNOFF FROM AREA ABOVE LAKE TAPPAN AND BELOW DEFOREST
   38         M      1           22.0          22.0
   39         P           22.0    104    115    124    135    142
   40         T                                              1.0   0.10
   41         W    5.0    9.2
   42         X     -1   -.05    2.0
   43         K      2      5                                  1
   44         K1     COMBINE DEFOREST ROUTED OUTFLOWS WITH SUBAREA INFLOWS TO LAKE TAPPAN
   45         K      1      6                                  1
   46         K1               ROUTED COMBINED FLOWS THROUGH LAKE TAPPAN
   47         Y                           1      1
   48         Y1     1                                      9250     -1
   49         Y4    49   52.5     55     57   59.5     62     64
   50         Y5     0   5000  10000  15000  25000  35000  45000
```

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51          KS     0     400    1500    2500    9250   10650   15600   19400
52          KS    33      40      43      45      49      55      60      64.
53          KS    49
54          KO    64     3.1     1.9     350
55          K      1       7                                             1
56          KI      CHANNEL ROUTING -MODIFIED PULS- STATION 6 TO 7
57          Y                                   1       1
58          YI     1                                                     -1
59          YO  0.10   0.045    0.10      34      70     900  0.0006
60          YT     0      70     200      40     225      37     225      34     275      34
61          YT   275      37     325      40     500      70
62          K      1       6                                             1
63          KI      CHANNEL ROUTING -MODIFIED PULS- STATION 7 TO 8
64          Y                                   1       1
65          YI     1                                                     -1
66          YO  0.10   0.045    0.10      32      60    3100  0.0006
67          YT     0      60     100      50     825      35     825      32     875      32
68          YT   875      35    1100      40    1200      60
69          K      1       9                                             1
70          KI      CHANNEL ROUTING -MODIFIED PULS- STATION 8 TO 9
71          Y                                   1       1
72          YI     1                                                     -1
73          YO  0.10   0.045     0.1      28      50    6500  0.0006
74          YT     0      50     500      40     700      30     750      28     800      28
75          YT   850      30    1300      40    1550      50
76          K     99
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PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

     RUNOFF HYDROGRAPH AT          1
     ROUTE HYDROGRAPH TO           2
     ROUTE HYDROGRAPH TO           3
     RUNOFF HYDROGRAPH AT          4
     COMBINE  2 HYDROGRAPHS AT     5
     ROUTE HYDROGRAPH TO           6
     ROUTE HYDROGRAPH TO           7
     ROUTE HYDROGRAPH TO           8
     ROUTE HYDROGRAPH TO           9
     END OF NETWORK
```

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
  LAST MODIFICATION  29 SEP 78
**********

RUN  DATE= 02/09/79
     TIME= 19.48.16.
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NEW JERSEY DAM SAFETY - LAKE TAPPAN I.D. NO. 00246
HYDRAULIC-HYDROLOGIC ANALYSIS 302-03
PROBABLE MAXIMUM FLOOD -RDE-

JOB SPECIFICATION

IO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
110	1	0	0	0	0	0	0	0	0

JOPER	NUT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1

RTIOS= .25 .50 .75 1.00

SUB-AREA RUNOFF COMPUTATION

OUTFLOWS FROM BEFORREST LAKE

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISHOW	ISAME	LOCAL
-1	0	26.60	0.00	26.00	.60	0.000	0	0	0

INPUT HYDROGRAPH

3.	6.	9.	12.	14.	16.	19.	21.	23.	24.
26.	28.	29.	31.	32.	36.	44.	61.	97.	129.
173.	232.	300.	376.	456.	538.	620.	699.	772.	836.
891.	937.	976.	1013.	1052.	1095.	1146.	1215.	1313.	1459.
1681.	2004.	2445.	3004.	3731.	4622.	6108.	7945.	9876.	10572.
12017.	13259.	14300.	15046.	15478.	15610.	15487.	15158.	14674.	14076.
13398.	12694.	11984.	11221.	10483.	9748.	9142.	8519.	7929.	7362.
6864.	6402.	5986.	5580.	5217.	4873.	4559.	4272.	3998.	3736.
3512.	3339.	3170.	3006.	2846.	2691.	2541.	2399.	2265.	2137.
2016.	1902.	1795.	1693.	1597.	1506.	1421.	1341.	1265.	1193.
1123.	1063.	1003.	947.	894.	844.	797.	753.	711.	672.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	19610.	19211.	11720.	9654.	410930.
CMS	462.	431.	332.	180.	11962.
INCHES		9.32	16.39	21.73	24.42
MM		135.11	416.42	402.48	620.17
AC-FT		7543.	23246.	33694.	34620.
THOUS CU M		9304.	28674.	41499.	42704.

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HYDROGRAPH ROUTING

ROUTING OUTFLOW TO STATION 2 / ABOVE LAKE TAPPAN

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELMVT	ELMAX	RLNTH	SEL
.1000	.0450	.1000	57.0	80.0	4000.	.00030

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00	80.00	200.00	70.00	375.00	60.00	379.00	57.00	429.00	57.00	
429.00	59.00	950.00	60.00	1600.00	80.00					

STORAGE	0.00	5.56	15.39	72.14	142.93	220.45	304.70	395.67	493.38	597.81
	708.97	826.87	951.74	1083.68	1222.68	1368.74	1521.97	1682.06	1849.32	2023.65
OUTFLOW	0.00	35.20	122.55	396.55	940.44	1706.05	2683.25	3869.81	5267.04	6878.13
	8737.41	10757.77	13033.08	15545.15	18300.73	21306.50	24569.14	28095.41	31892.03	35965.73
STAGE	57.00	59.21	59.42	60.63	61.84	63.05	64.26	65.47	66.68	67.89
	69.11	70.32	71.53	72.74	73.95	75.16	76.37	77.58	78.79	80.00
FLOW	0.00	35.20	122.55	396.55	940.44	1706.05	2683.25	3869.81	5267.04	6878.13
	8737.41	10797.97	13033.08	15545.15	18300.73	21306.50	24569.14	28095.41	31892.03	35965.73

STATION 2, PLAN 1, RTIO 4

OUTFLOW

3.	4.	5.	6.	10.	12.	15.	17.	19.	21.
23.	25.	26.	28.	30.	32.	35.	44.	60.	84.
119.	148.	187.	237.	297.	363.	452.	552.	641.	719.
799.	849.	901.	947.	997.	1041.	1087.	1141.	1212.	1313.
1462.	1683.	2031.	2482.	3087.	3923.	5068.	6427.	7934.	9489.
11046.	12489.	13600.	14549.	15176.	15500.	15543.	15369.	14969.	14444.
13822.	13134.	12441.	11712.	10973.	10267.	9596.	8956.	8354.	7779.
7248.	6754.	6310.	5892.	5508.	5153.	4828.	4522.	4234.	3961.
3720.	3514.	3332.	3161.	2996.	2837.	2682.	2545.	2407.	2273.
2146.	2025.	1911.	1803.	1701.	1614.	1527.	1442.	1362.	1285.
1211.	1143.	1077.	1019.	962.	913.	869.	824.	779.	737.

STOR

0.	1.	1.	1.	1.	2.	2.	2.	3.	3.
3.	4.	4.	4.	4.	5.	5.	6.	8.	11.
15.	21.	27.	39.	51.	65.	79.	92.	104.	114.
123.	131.	139.	144.	149.	153.	158.	163.	170.	181.
196.	218.	244.	267.	336.	399.	479.	549.	662.	754.
840.	917.	982.	1031.	1064.	1081.	1084.	1073.	1053.	1026.
993.	957.	919.	879.	839.	799.	760.	723.	687.	653.
620.	590.	561.	536.	509.	485.	463.	441.	421.	402.
384.	368.	354.	341.	329.	318.	305.	293.	281.	269.
258.	246.	239.	229.	220.	211.	202.	196.	186.	178.
170.	163.	157.	151.	145.	139.	134.	128.	122.	116.

STAGE

57.1	57.1	57.2	57.2	57.3	57.4	57.5	57.5	57.6	57.7
57.7	57.8	57.8	57.9	57.9	58.0	58.1	58.3	58.5	58.9
59.4	59.5	59.7	59.9	60.2	60.5	60.8	61.0	61.2	61.3
61.5	61.6	61.8	61.9	61.9	62.0	62.1	62.2	62.3	62.4
62.7	63.0	63.5	64.0	64.7	65.5	66.5	67.6	68.6	69.6
73.4	71.2	71.0	72.3	72.6	72.7	72.7	72.6	72.5	72.2
71.9	71.6	71.2	70.8	70.4	70.0	69.6	69.3	68.9	68.9
68.1	67.6	67.5	67.2	66.9	66.6	66.3	66.0	65.8	65.6
65.3	65.1	64.9	64.8	64.6	64.4	64.3	64.1	63.9	63.9
63.6	63.4	63.3	63.2	63.0	62.9	62.8	62.6	62.5	62.4
62.3	62.2	62.1	62.0	61.9	61.8	61.7	61.6	61.5	61.4

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	15543.	15172.	11701.	9693.	417504.
CMS	440.	430.	331.	169.	11822.
INCHES		9.31	16.37	23.72	24.33
AM		136.77	419.75	602.51	618.09
AC-FT		7523.	23209.	33635.	34504.
THOUS CU M		9280.	28628.	41488.	42561.

MAXIMUM STORAGE = 1084.

MAXIMUM STAGE IS 72.7

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HYDROGRAPH ROUTING

ROUTING OUTFLOW TO STATION 3 / ABOVE LAKE TAPPAN

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
3	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QMAN	QMAN	QMAN	ELMVT	ELMAX	RLNTH	SEL
.1000	.0450	.1000	92.0	98.0	15000.	.00030

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 93.00 300.00 60.00 1375.00 94.00 1375.00 92.00 1425.00 92.00
1425.00 94.00 1450.00 60.00 1600.00 98.00

STORAGE	0.00	25.37	79.00	261.14	590.31	1036.59	1610.33	2211.95	2838.39	3465.66
	4117.75	4786.67	5472.42	6175.00	6894.40	7630.63	8383.68	9153.56	9940.27	10743.90
OUTFLOW	0.00	92.67	177.95	481.85	1083.36	2076.32	3603.85	5872.54	8498.15	11537.94
	14976.54	18903.10	23009.81	27590.98	32542.54	37861.62	43546.31	49595.46	56008.53	62785.50
STAGE	92.00	93.47	94.99	96.42	97.89	99.37	60.84	62.32	63.79	65.26
	66.74	68.21	69.68	71.16	72.63	74.11	75.58	77.05	78.53	80.00
FLOW	0.00	92.67	177.95	481.85	1083.36	2076.32	3603.85	5872.54	8498.15	11537.94
	14976.54	18903.10	23009.81	27590.98	32542.54	37861.62	43546.31	49595.46	56008.53	62785.50

02-D

STATION 1, PLAN 1, RTIO 4

OUTFLOW

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
13.	15.	16.	18.	20.	22.	23.	24.	26.	36.	37.
47.	61.	80.	103.	132.	167.	201.	240.	286.	337.	
391.	449.	504.	564.	623.	690.	736.	790.	848.	906.	
976.	1062.	1190.	1366.	1600.	1915.	2409.	3101.	4016.	5244.	
6660.	8136.	9722.	11150.	12451.	13644.	14213.	14654.	14835.	14789.	
14594.	14170.	13676.	13104.	12473.	11810.	11169.	10544.	9920.	9308.	
8714.	8101.	7697.	7215.	6762.	6335.	5934.	5597.	5278.	4970.	
4675.	4390.	4143.	3909.	3692.	3529.	3370.	3213.	3060.	2910.	
2769.	2624.	2480.	2397.	2231.	2112.	2015.	1924.	1841.	1758.	
1672.	1590.	1511.	1435.	1361.	1292.	1225.	1163.	1103.	1091.	

STOR

1.	1.	2.	2.	2.	3.	3.	4.	5.	6.
6.	7.	9.	9.	10.	10.	11.	12.	14.	18.
23.	29.	37.	47.	59.	76.	93.	116.	144.	174.
208.	240.	273.	309.	336.	368.	398.	425.	459.	446.
523.	587.	627.	710.	810.	962.	1159.	1402.	1702.	2039.
2340.	2750.	3006.	3306.	3639.	3839.	3973.	4097.	4091.	4082.
4038.	3965.	3871.	3761.	3643.	3517.	3389.	3258.	3128.	3000.
2878.	2758.	2640.	2528.	2422.	2321.	2226.	2136.	2049.	1964.
1883.	1807.	1737.	1672.	1613.	1559.	1498.	1442.	1394.	1336.
1242.	1232.	1183.	1137.	1092.	1049.	1007.	968.	929.	889.
851.	813.	777.	742.	708.	676.	646.	617.	589.	563.

STAGE

92.1	92.1	92.1	92.1	92.1	92.2	92.2	92.2	92.3	92.3
92.4	92.4	92.5	92.5	92.6	92.6	92.7	92.7	92.8	93.0
93.3	93.6	93.8	94.1	94.4	94.8	95.1	95.2	95.5	95.7
96.0	96.2	96.5	96.6	96.8	96.9	97.0	97.2	97.3	97.5
97.6	97.9	98.1	98.3	98.7	99.1	99.7	60.3	61.1	61.9
62.8	63.6	64.4	65.1	65.7	66.1	66.4	66.6	66.7	66.7
66.6	66.4	66.2	65.9	65.7	65.4	65.1	64.8	64.5	64.2
63.9	63.6	63.3	63.1	62.8	62.6	62.4	62.1	61.9	61.7
61.5	61.3	61.2	61.0	60.9	60.7	60.6	60.4	60.3	60.1
60.0	59.9	59.7	59.6	59.5	59.4	59.3	59.1	59.0	58.9
58.8	58.6	58.5	58.4	58.3	58.2	58.1	58.0	57.9	57.8

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	14835.	14491.	11362.	9617.	410730.
CMS	420.	410.	322.	159.	11630.
INCHES		9.87	15.89	23.57	23.94
MM		120.72	403.71	598.79	608.03
AC-FT		7186.	22537.	33425.	33943.
THOUS CU M		8863.	27799.	41229.	41860.

MAXIMUM STORAGE = 4091.

MAXIMUM STAGE IS 66.7

SUB-AREA RUNOFF COMPUTATION

RUNOFF FROM AREA ABOVE LAKE TAPPAN AND BELOW DEFOREST

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	0	0	8	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	0	22.00	0.00	22.00	0.00	0.000	0	0	0

PRECIP DATA

SPFE	PRS	R6	R12	R24	R48	R72	R96
0.00	22.00	104.00	119.00	124.00	139.00	142.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .027

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA

TC= 5.00 R= 9.20 NTA= 0

RECESSION DATA

STRTQ= -1.00 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 92 END-OF-PERIOD ORDINATES, LAG= 4.09 HOURS, CP= .40 VOL= 1.00

90.	357.	711.	1029.	1194.	1167.	1047.	939.	842.	755.
677.	607.	545.	489.	438.	393.	353.	316.	284.	254.
228.	205.	184.	165.	148.	132.	119.	107.	96.	86.
77.	69.	62.	55.	50.	45.	40.	36.	32.	29.
26.	23.	21.	19.	17.	15.	13.	12.	11.	10.
9.	8.								

END-OF-PERIOD FLOW

HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.00	1	.01	0.00	.01	21.
2.00	2	.01	0.00	.01	20.
3.00	3	.01	0.00	.01	19.
4.00	4	.01	0.00	.01	17.
5.00	5	.01	0.00	.01	16.
6.00	6	.01	0.00	.01	15.
7.00	7	.03	0.00	.03	14.
8.00	8	.03	0.00	.03	13.
9.00	9	.03	0.00	.03	12.
10.00	10	.03	0.00	.03	11.
11.00	11	.03	0.00	.03	11.
12.00	12	.03	0.00	.03	10.
13.00	13	.17	0.00	.17	9.
14.00	14	.20	0.00	.20	9.
15.00	15	.25	0.00	.25	8.
16.00	16	.64	.42	.22	48.
17.00	17	.24	.14	.10	169.
18.00	18	.10	.00	.10	380.
19.00	19	.01	0.00	.01	562.
20.00	20	.01	0.00	.01	703.
21.00	21	.01	0.00	.01	741.
22.00	22	.01	0.00	.01	700.
23.00	23	.01	0.00	.01	636.
0.00	24	.01	0.00	.01	571.
1.00	25	.11	.01	.10	513.
2.00	26	.11	.01	.10	464.
3.00	27	.11	.01	.10	423.
4.00	28	.12	.02	.10	390.
5.00	29	.11	.01	.10	363.
6.00	30	.11	.01	.10	340.
7.00	31	.33	.23	.10	340.
8.00	32	.33	.23	.10	402.
9.00	33	.33	.23	.10	544.
10.00	34	.33	.23	.10	760.
11.00	35	.33	.23	.10	1014.
12.00	36	.33	.23	.10	1264.
13.00	37	1.97	1.79	.10	1630.
14.00	38	2.27	2.17	.10	2431.
15.00	39	2.84	2.74	.10	3910.
16.00	40	7.17	7.07	.10	6565.
17.00	41	2.65	2.55	.10	10444.
18.00	42	2.08	1.98	.10	14989.
19.00	43	.16	.06	.10	18617.
20.00	44	.16	.06	.10	20679.
21.00	45	.16	.05	.10	20742.
22.00	46	.16	.05	.10	19459.
23.00	47	.16	.06	.10	17733.
0.00	48	.16	.06	.10	16002.
1.00	49	.01	0.00	.01	14443.
2.00	50	.01	0.00	.01	13027.
3.00	51	.01	0.00	.01	11732.
4.00	52	.01	0.00	.01	10546.
5.00	53	.01	0.00	.01	9465.
6.00	54	.01	0.00	.01	8489.
7.00	55	.02	0.00	.02	7614.
8.00	56	.02	0.00	.02	6929.
9.00	57	.02	0.00	.02	6125.
10.00	58	.02	0.00	.02	5494.
11.00	59	.02	0.00	.02	4927.
12.00	60	.02	0.00	.02	4419.
13.00	61	.11	.01	.10	3965.
14.00	62	.13	.03	.10	3563.
15.00	63	.16	.06	.10	3209.
16.00	64	.41	.31	.10	2939.
17.00	65	.15	.05	.10	2759.
18.00	66	.12	.02	.10	2641.
19.00	67	.01	0.00	.01	2532.
20.00	68	.01	0.00	.01	2383.
21.00	69	.01	0.00	.01	2184.
22.00	70	.01	0.00	.01	1979.
23.00	71	.01	0.00	.01	1794.
0.00	72	.01	0.00	.01	1646.
1.00	73	0.00	0.00	0.00	1522.
2.00	74	0.00	0.00	0.00	1276.
3.00	75	0.00	0.00	0.00	1144.
4.00	76	0.00	0.00	0.00	1031.
5.00	77	0.00	0.00	0.00	962.
6.00	78	0.00	0.00	0.00	897.
7.00	79	0.00	0.00	0.00	837.
8.00	80	0.00	0.00	0.00	781.
9.00	81	0.00	0.00	0.00	729.
10.00	82	0.00	0.00	0.00	680.
11.00	83	0.00	0.00	0.00	634.
12.00	84	0.00	0.00	0.00	592.
13.00	85	0.00	0.00	0.00	552.
14.00	86	0.00	0.00	0.00	515.
15.00	87	0.00	0.00	0.00	481.
16.00	88	0.00	0.00	0.00	449.
17.00	89	0.00	0.00	0.00	419.
18.00	90	0.00	0.00	0.00	391.
19.00	91	0.00	0.00	0.00	364.
20.00	92	0.00	0.00	0.00	340.
21.00	93	0.00	0.00	0.00	317.
22.00	94	0.00	0.00	0.00	296.
23.00	95	0.00	0.00	0.00	276.
0.00	96	0.00	0.00	0.00	259.
1.00	97	0.00	0.00	0.00	240.
2.00	98	0.00	0.00	0.00	224.
3.00	99	0.00	0.00	0.00	209.
4.00	100	0.00	0.00	0.00	195.
5.00	101	0.00	0.00	0.00	182.
6.00	102	0.00	0.00	0.00	170.
7.00	103	0.00	0.00	0.00	159.
8.00	104	0.00	0.00	0.00	148.
9.00	105	0.00	0.00	0.00	138.
10.00	106	0.00	0.00	0.00	129.
11.00	107	0.00	0.00	0.00	120.
12.00	108	0.00	0.00	0.00	112.
13.00	109	0.00	0.00	0.00	105.
14.00	110	0.00	0.00	0.00	98.
	SUM	25.84	21.27	4.57	317140.
		(656.3(	540.1(	116.1(	8980.40)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	20742.	10779.	10807.	4337.	317095.
CMS	587.	932.	306.	123.	8979.
INCHES		7.66	17.64	21.23	21.96
MM		194.61	447.97	539.34	547.66
AC-FT		9312.	21435.	25807.	26205.
THOUS CU M		11496.	26440.	31833.	32324.

HYDROGRAPH AT STA 4 FOR PLAN 1, RTIO 4

21.	20.	19.	17.	16.	15.	14.	13.	12.	11.
11.	10.	9.	9.	8.	48.	169.	340.	562.	705.
761.	788.	636.	571.	513.	464.	423.	390.	363.	340.
340.	432.	544.	760.	1014.	1264.	1638.	2431.	3910.	6565.
10464.	14869.	18617.	20679.	20742.	19459.	17733.	16002.	14443.	13027.
11752.	10546.	9465.	8469.	7614.	6829.	6129.	5494.	4927.	4419.
3965.	3560.	3209.	2938.	2759.	2641.	2532.	2383.	2186.	1970.
1769.	1596.	1422.	1276.	1144.	1031.	962.	897.	837.	781.
729.	680.	634.	592.	552.	515.	481.	449.	419.	391.
364.	340.	317.	296.	276.	258.	240.	224.	209.	195.
182.	170.	159.	148.	138.	129.	120.	112.	105.	98.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	20742.	18779.	18087.	4337.	317089.
CMS	587.	532.	386.	123.	8979.
INCHES		7.66	17.64	21.23	21.56
MM		194.61	447.97	539.34	547.66
AC-FT		9312.	21439.	25807.	26205.
THOUS CU M		11486.	26440.	31833.	32324.

COMBINE HYDROGRAPHS

COMBINE DEFOREST ROUTED OUTFLOWS WITH SUBAREA INFLOWS TO LAKE TAPPAN

ISTAG	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	2	0	0	0	0	1	0	0

SUM OF 2 HYDROGRAPHS AT 5 PLAN 1 RTIO 4

24.	23.	22.	21.	21.	21.	21.	21.	22.	23.
24.	25.	26.	27.	28.	69.	192.	386.	592.	748.
787.	782.	716.	674.	645.	631.	624.	630.	649.	676.
731.	847.	1040.	1324.	1630.	1944.	2373.	3222.	4756.	7472.
11460.	15951.	17888.	22049.	22342.	21173.	20142.	19183.	18459.	18271.
18360.	18704.	19187.	19649.	20046.	20314.	20339.	20149.	19762.	19209.
18519.	17730.	16895.	16042.	15233.	14452.	13781.	12927.	12186.	11774.
10492.	9767.	9111.	8490.	7987.	7366.	6895.	6496.	6116.	5751.
5494.	5076.	4778.	4581.	4246.	4065.	3850.	3681.	3479.	3301.
3129.	2964.	2805.	2653.	2507.	2370.	2256.	2152.	2058.	1955.
1854.	1760.	1670.	1583.	1500.	1420.	1346.	1275.	1208.	1149.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	22342.	20690.	19038.	9069.	727793.
CMS	633.	586.	539.	279.	20609.
INCHES		1.98	14.36	22.29	22.84
MM		50.36	364.23	566.21	580.17
AC-FT		10239.	37761.	98701.	60148.
THOUS CU M		12695.	46578.	72607.	74192.

HYDROGRAPH ROUTING

ROUTED COMBINED FLOWS THROUGH LAKE TAPPAN

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
6	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	5250.	-1

STAGE	49.00	52.50	55.00	57.00	59.50	62.00	64.00
FLOW	0.00	5000.00	10000.00	15000.00	25000.00	35000.00	45000.00
CAPACITY=	0.	400.	1500.	2500.	5250.	10650.	15600.	19400.
ELEVATION=	33.	40.	43.	45.	49.	55.	60.	64.

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
49.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
64.0	3.1	1.5	350.

HYDROGRAPH ROUTING

CHANNEL ROUTING -MODIFIED PULS- STATION 6 TO 7

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
7	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPAP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QMIN	QMAX	QINC	ELMVT	ELMAX	RLNTH	SEL
.1000	.0490	.1000	34.0	70.0	500.	.00060

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 70.00 200.00 40.00 225.00 37.00 225.00 34.00 275.00 34.00
275.00 37.00 325.00 40.00 500.00 70.00

STORAGE	0.00	1.09	2.26	4.30	7.16	10.56	14.91	18.94	23.89	29.36
	35.34	41.83	48.84	56.37	64.41	72.97	82.04	91.63	101.73	112.35
OUTFLOW	0.00	112.06	347.87	720.65	1269.91	1992.23	2891.03	3975.76	5252.32	6730.14
	8417.96	10324.92	12490.94	14829.61	17443.27	20313.94	23439.95	26830.92	30514.76	34476.70
STAGE	34.00	35.69	37.79	39.68	41.58	43.47	45.37	47.26	49.16	51.05
	52.95	54.84	56.74	58.63	60.53	62.42	64.32	66.21	68.11	70.00
FLOW	0.00	112.06	347.87	720.65	1269.91	1992.23	2891.03	3975.76	5252.32	6730.14
	8417.96	10324.92	12490.94	14829.61	17443.27	20313.94	23439.95	26830.92	30514.76	34476.70

STATION 6, PLAN 1, RATIO 4

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

5.	6.	8.	9.	11.	12.	13.	14.	15.	16.
17.	18.	19.	20.	21.	24.	37.	60.	120.	187.
256.	322.	373.	413.	443.	467.	487.	504.	521.	538.
559.	587.	631.	709.	796.	910.	1071.	1284.	1617.	2179.
3060.	4370.	6421.	8861.	11417.	13672.	15202.	16239.	16916.	17302.
17575.	17832.	18129.	18472.	18941.	19200.	19500.	19698.	19766.	19691.
19471.	19112.	18632.	18034.	17411.	16727.	16021.	15395.	14773.	14109.
13411.	12701.	11997.	11307.	10635.	9991.	9509.	9036.	8577.	8132.
7732.	7346.	6891.	6513.	6153.	5815.	5501.	5207.	4930.	4758.
4568.	4381.	4197.	4018.	3839.	3667.	3500.	3341.	3188.	3042.
2932.	2767.	2637.	2513.	2393.	2278.	2168.	2063.	1961.	1865.

STORAGE

9252.	9253.	9255.	9256.	9257.	9258.	9258.	9259.	9259.	9260.
9261.	9261.	9262.	9262.	9263.	9265.	9273.	9293.	9326.	9369.
9413.	9453.	9485.	9510.	9529.	9544.	9557.	9569.	9578.	9589.
9632.	9620.	9669.	9691.	9751.	9829.	9925.	6053.	6269.	6617.
7193.	8004.	9039.	10137.	11134.	11983.	12626.	12769.	12930.	13034.
13107.	13177.	13256.	13369.	13466.	13545.	13629.	13679.	13697.	13677.
13618.	13521.	13392.	13237.	13063.	12879.	12689.	12492.	12279.	12052.
11814.	11572.	11332.	11090.	10867.	10648.	10429.	10216.	10010.	9809.
9616.	9430.	9251.	9081.	8919.	8767.	8625.	8492.	8369.	8249.
8129.	8010.	7894.	7780.	7669.	7560.	7455.	7353.	7250.	7166.
7078.	6993.	6912.	6833.	6758.	6685.	6616.	6549.	6490.	6429.

STAGE

47.8	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0
47.8	47.8	49.0	49.0	49.0	49.0	49.0	49.0	49.1	49.1
47.2	49.2	49.3	49.3	49.3	49.3	49.3	49.4	49.4	49.4
49.4	49.4	49.4	49.5	49.6	49.6	49.7	49.9	50.1	50.5
51.1	52.1	53.2	54.4	55.5	56.3	56.8	57.1	57.3	57.4
57.5	57.5	57.6	57.7	57.8	57.9	58.0	58.1	58.1	58.1
58.0	57.9	57.8	57.6	57.4	57.3	57.1	56.9	56.6	56.4
56.2	55.9	55.7	55.5	55.2	55.0	54.8	54.5	54.3	54.1
53.9	53.6	53.4	53.3	53.1	52.9	52.8	52.6	52.5	52.3
52.2	52.1	51.9	51.8	51.7	51.6	51.5	51.3	51.2	51.1
51.0	50.9	50.8	50.8	50.7	50.6	50.5	50.4	50.4	50.3

PEAK OUTFLOW IS 19766. AT TIME 59.00 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	19766.	19947.	17660.	9760.	713603.
CMS	560.	554.	500.	276.	20207.
INCHES		3.68	13.30	22.06	22.40
MM		93.49	337.88	560.28	569.06
AC-FT		9693.	35029.	58078.	58975.
THOUS CU M		11956.	43207.	71630.	72749.

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STATION 7, PLAN 1, RTIO 4

OUTFLOW

3.	5.	8.	9.	11.	12.	13.	14.	15.	16.
17.	18.	19.	19.	20.	23.	35.	64.	113.	185.
252.	320.	369.	411.	441.	466.	485.	903.	919.	937.
957.	985.	628.	694.	789.	910.	1060.	1260.	1595.	2132.
3015.	4306.	6310.	8762.	11309.	13600.	15134.	16208.	16896.	17293.
17504.	17824.	18116.	18460.	18826.	19188.	19490.	19693.	19766.	19697.
19481.	19128.	18651.	18077.	17439.	16754.	16047.	15416.	14798.	14134.
13438.	12729.	12029.	11336.	10662.	10018.	9524.	9060.	8592.	8154.
7718.	7308.	6906.	6531.	6167.	9830.	9513.	9221.	4761.	4766.
4578.	4387.	4206.	4024.	3849.	3675.	3509.	3348.	3196.	3049.
2909.	2774.	2644.	2519.	2399.	2284.	2174.	2068.	1967.	1871.

STOR

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	1.	1.	1.
2.	2.	2.	3.	3.	3.	3.	3.	3.	3.
3.	4.	4.	4.	5.	5.	6.	7.	9.	11.
15.	20.	29.	37.	49.	92.	57.	61.	63.	64.
65.	66.	66.	67.	69.	70.	71.	71.	71.	72.
70.	69.	69.	68.	66.	62.	60.	58.	56.	55.
52.	50.	47.	45.	43.	41.	39.	38.	36.	34.
33.	31.	30.	29.	27.	26.	25.	24.	23.	22.
21.	21.	20.	19.	18.	18.	17.	16.	16.	15.
15.	14.	13.	13.	12.	12.	11.	11.	10.	10.

STAGE

34.1	34.1	34.1	34.2	34.2	34.2	34.2	34.2	34.3	34.3
34.3	34.3	34.3	34.3	34.3	34.4	34.6	35.1	35.9	36.9
37.8	37.6	37.9	38.1	38.2	38.4	38.5	38.6	38.7	38.8
38.9	39.0	39.2	39.6	39.9	40.3	40.9	41.6	42.4	43.8
45.6	47.8	50.5	53.3	55.7	57.6	58.9	59.6	60.1	60.4
60.6	60.8	61.0	61.2	61.4	61.7	61.9	62.0	62.1	62.0
61.9	61.6	61.3	60.9	60.5	60.0	59.5	59.1	58.6	58.1
57.5	57.0	56.4	55.7	55.1	54.5	54.0	53.6	53.1	52.7
52.2	51.7	51.3	50.8	50.3	49.9	49.5	49.1	48.7	48.4
48.2	47.9	47.6	47.3	47.0	46.7	46.4	46.2	45.9	45.6
45.4	45.1	44.8	44.6	44.3	44.1	43.9	43.6	43.4	43.2

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	19766.	19947.	17660.	9760.	713492.
CMS	560.	554.	500.	276.	20204.
INCHES		3.66	13.30	22.09	22.39
MM		93.50	337.86	560.17	568.76
AC-FT		9693.	35027.	58075.	58965.
THOUS CU M		11956.	43209.	71634.	72733.

MAXIMUM STORAGE = 71.

MAXIMUM STAGE IS 62.1

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HYDROGRAPH ROUTING

CHANNEL ROUTING -MODIFIED PULS- STATION 7 TO 6

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
0	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IPRT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QMIN	QMAX	QMIN	ELMVT	ELMAX	ALNTH	SEL
.1000	.0450	.1300	32.0	60.0	3100.	.00060

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

	0.00	60.00	100.00	50.00	825.00	35.00	825.00	32.00	875.00	32.00
	875.00	35.00	1100.00	40.00	1200.00	60.00				
STORAGE	0.00	5.24	10.49	22.44	48.00	89.60	143.00	206.82	278.00	357.59
	449.33	541.32	645.55	756.20	869.30	984.72	1102.46	1222.52	1344.89	1469.58
OUTFLOW	0.00	74.47	220.11	475.18	905.88	1596.21	2644.83	4071.84	5880.79	8031.42
	10681.63	13590.70	17019.05	21206.07	25916.48	31053.68	36609.44	42577.49	48953.88	55732.31
STAGE	32.00	33.47	34.93	36.42	37.89	39.37	40.84	42.32	43.79	45.26
	46.74	48.21	49.68	51.16	52.63	54.11	55.58	57.05	58.53	60.00
FLOW	0.00	74.47	220.11	475.18	905.88	1596.21	2644.83	4071.84	5880.79	8031.42
	10681.63	13590.70	17019.05	21206.07	25916.48	31053.68	36609.44	42577.49	48953.88	55732.31

STATION 6, PLAN 1, RTIO 4

OUTFLOW

3.	4.	6.	8.	9.	11.	12.	13.	14.	15.
16.	17.	18.	19.	20.	21.	27.	44.	78.	156.
225.	282.	339.	386.	423.	451.	474.	498.	987.	924.
343.	969.	990.	649.	724.	825.	955.	1127.	1376.	1792.
2496.	3687.	5314.	7647.	10250.	12721.	14604.	15644.	16660.	17169.
17495.	17740.	18021.	18347.	18708.	19073.	19397.	19636.	19750.	19727.
19559.	19249.	18810.	18266.	17644.	16976.	16313.	15643.	15026.	14381.
13696.	13004.	12298.	11602.	10922.	10275.	9722.	9251.	8785.	8334.
7902.	7489.	7084.	6698.	6328.	5979.	5662.	5362.	5086.	4859.
4660.	4488.	4294.	4112.	3940.	3768.	3598.	3436.	3277.	3127.
2984.	2846.	2714.	2591.	2474.	2357.	2243.	2139.	2031.	1931.

STOR

0.	0.	0.	1.	1.	1.	1.	1.	1.	1.
2.	1.	1.	1.	1.	2.	2.	3.	3.	4.
10.	13.	16.	18.	20.	21.	22.	23.	24.	25.
27.	28.	30.	33.	36.	44.	52.	62.	77.	100.
136.	196.	256.	344.	433.	513.	572.	618.	635.	650.
656.	665.	672.	681.	690.	700.	706.	715.	719.	717.
713.	704.	693.	679.	662.	644.	624.	604.	585.	565.
545.	522.	500.	477.	456.	434.	415.	399.	383.	368.
353.	336.	323.	309.	295.	282.	270.	258.	247.	238.
231.	223.	216.	208.	201.	193.	186.	179.	172.	165.
159.	153.	147.	141.	135.	129.	123.	117.	112.	107.

STAGE

32.1	32.1	32.1	32.1	32.2	32.2	32.2	32.3	32.3	32.3
32.3	32.3	32.4	32.4	32.4	32.4	32.5	32.9	33.3	34.1
34.9	35.3	35.6	35.9	36.1	36.3	36.4	36.5	36.5	36.6
36.7	36.7	36.8	37.0	37.3	37.6	38.0	38.4	38.9	39.6
40.6	41.8	43.3	45.0	46.9	47.8	48.6	49.2	49.5	49.7
49.8	49.9	50.0	50.2	50.3	50.4	50.5	50.6	50.6	50.6
50.6	50.5	50.3	50.1	49.9	49.7	49.4	49.1	48.8	48.6
48.3	47.9	47.6	47.2	46.9	46.5	46.2	46.0	45.7	45.4
45.2	44.9	44.6	44.4	44.1	43.9	43.6	43.4	43.2	43.0
42.8	42.7	42.5	42.3	42.2	42.0	41.8	41.7	41.5	41.3
41.2	41.1	40.9	40.8	40.6	40.4	40.3	40.1	40.0	39.8

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	19750.	19938.	17649.	9752.	712191.
CMS	559.	553.	500.	276.	20167.
INCHES		3.69	13.29	22.04	22.35
AM		93.49	337.66	559.74	567.73
AC-FT		9688.	35006.	58030.	58859.
THOUS CU M		11950.	43179.	71579.	72601.

MAXIMUM STORAGE = 719.

MAXIMUM STAGE IS 50.6

D-29

HYDROGRAPH ROUTING

CHANNEL ROUTING -MODIFIED PULS- STATION 8 TO 9

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
9	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QW(1)	QW(2)	QW(3)	ELMVT	ELMAX	RLNTH	SEL
.1300	.0450	.1000	28.0	50.0	6500.	.00060

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00	50.00	500.00	40.00	700.00	30.00	750.00	28.00	800.00	28.00	
850.00	30.00	1300.00	40.00	1950.00	50.00					

STORAGE	0.00	13.64	37.40	73.36	122.33	184.30	259.28	347.26	448.25	562.24
	689.23	823.64	984.91	1159.19	1348.47	1548.76	1756.06	1986.35	2231.66	2491.97
OUTFLOW	0.00	66.36	280.29	700.31	1306.53	2112.12	3131.00	4377.30	5865.07	7609.19
	9620.31	11897.91	14490.39	17410.90	20692.70	24324.28	28326.00	32713.95	37499.52	42697.27
STAGE	28.00	29.16	30.32	31.47	32.63	33.79	34.95	36.11	37.26	38.42
	39.58	40.74	41.89	43.05	44.21	45.37	46.53	47.68	48.84	50.00
FLOW	0.00	66.36	280.29	700.31	1306.53	2112.12	3131.00	4377.30	5865.07	7609.19
	9620.31	11897.91	14490.39	17410.80	20692.70	24324.28	28326.00	32713.95	37499.52	42697.27

STATION 9, PLAN 1, RTIO 4

OUTFLOW

3.	5.	6.	9.	6.	7.	9.	10.	11.	12.
13.	14.	15.	16.	17.	18.	20.	25.	37.	64.
131.	197.	259.	322.	376.	416.	446.	469.	489.	506.
524.	543.	560.	604.	658.	739.	860.	976.	1103.	1193.
1932.	2726.	3997.	5867.	8268.	10931.	13127.	14847.	16014.	16767.
17232.	17550.	17829.	18129.	18465.	18824.	19171.	19462.	19656.	19728.
19656.	19443.	19094.	18625.	18059.	17427.	16776.	16113.	15466.	14832.
14178.	13502.	12807.	12107.	11425.	10762.	10149.	9617.	9143.	8681.
8235.	7809.	7400.	7005.	6623.	6259.	5919.	5610.	5318.	5056.
4835.	4638.	4448.	4265.	4086.	3913.	3763.	3575.	3413.	3258.
3109.	2969.	2833.	2703.	2580.	2462.	2365.	2233.	2129.	2024.

STOR

1.	1.	1.	1.	1.	1.	2.	2.	2.	3.
3.	3.	3.	3.	4.	4.	4.	5.	8.	13.
21.	28.	35.	41.	46.	49.	52.	54.	55.	57.
58.	60.	62.	65.	70.	76.	85.	96.	111.	134.
170.	230.	320.	443.	604.	764.	903.	1005.	1076.	1117.
1144.	1163.	1176.	1195.	1214.	1235.	1254.	1271.	1282.	1286.
1282.	1270.	1250.	1223.	1191.	1156.	1118.	1079.	1042.	1005.
966.	926.	884.	842.	800.	760.	722.	699.	659.	630.
632.	575.	547.	523.	498.	474.	452.	431.	411.	391.
378.	365.	352.	339.	327.	315.	303.	291.	279.	268.
258.	247.	237.	228.	219.	210.	201.	193.	185.	179.

STAGE

28.1	28.1	28.1	28.1	28.1	28.1	28.2	28.2	28.2	28.2
28.2	28.3	28.3	28.3	28.3	28.3	28.4	28.4	28.6	29.1
29.5	29.9	30.2	30.4	30.6	30.7	30.8	30.8	30.9	30.9
31.0	31.0	31.1	31.2	31.4	31.5	31.7	32.0	32.4	32.8
33.5	34.5	35.8	37.3	38.8	40.2	41.3	42.0	42.5	42.8
43.0	43.1	43.2	43.3	43.4	43.5	43.7	43.8	43.8	43.9
43.8	43.8	43.8	43.5	43.3	43.1	42.8	42.5	42.3	42.0
41.8	41.5	41.1	40.8	40.5	40.2	39.8	39.6	39.3	39.0
38.8	38.5	38.3	38.0	37.8	37.5	37.3	37.1	36.8	36.6
36.5	36.3	36.2	36.0	35.8	35.7	35.5	35.4	35.2	35.1
34.9	34.8	34.6	34.5	34.3	34.2	34.1	33.9	33.8	33.7

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	19726.	19513.	17617.	9738.	710091.
CMS	559.	553.	499.	276.	20106.
INCHES		3.67	13.27	22.01	22.28
HA		93.33	337.05	558.95	566.03
AC-FT		9676.	34943.	57948.	58692.
THOUS CU M		11935.	43102.	71478.	72383.

MAXIMUM STORAGE = 1286.

MAXIMUM STAGE IS 43.9

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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .25	RATIO 2 .50	RATIO 3 .75	RATIO 4 1.00
HYDROGRAPH AT	1	26.60	1	1903.	7005.	11708.	15610.
	(	68.89)	(	110.91)(	221.01)(	331.52)(	442.03)(
ROUTED TO	2	26.60	1	3874.	7766.	11655.	15543.
	(	68.89)	(	109.69)(	219.90)(	330.04)(	440.12)(
ROUTED TO	3	26.60	1	3388.	7195.	10999.	14835.
	(	68.89)	(	95.95)(	203.75)(	311.45)(	420.07)(
HYDROGRAPH AT	4	22.80	1	5185.	10371.	15556.	20742.
	(	59.05)	(	146.83)(	293.67)(	440.50)(	587.34)(
2 COMBINED	5	49.40	1	5529.	11107.	16703.	22342.
	(	127.95)	(	156.56)(	314.51)(	472.99)(	632.65)(
ROUTED TO	6	49.40	1	4167.	9112.	14370.	19768.
	(	127.95)	(	118.00)(	258.02)(	406.90)(	559.72)(
ROUTED TO	7	49.40	1	4167.	9112.	14370.	19766.
	(	127.95)	(	118.00)(	258.03)(	406.90)(	559.70)(
ROUTED TO	8	49.40	1	4163.	9103.	14361.	19758.
	(	127.95)	(	117.89)(	257.76)(	406.64)(	559.27)(
ROUTED TO	9	49.40	1	4159.	9098.	14339.	19726.
	(	127.95)	(	117.76)(	257.59)(	406.04)(	558.38)(

PLAN 1 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.25	3874.	65.5	57.00
.50	7766.	68.5	57.00
.75	11655.	70.8	57.00
1.00	15543.	72.7	57.00

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.25	3388.	60.6	62.00
.50	7195.	63.1	60.00
.75	10999.	65.0	60.00
1.00	14835.	66.7	59.00

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	49.00	49.00	64.00
	STORAGE	9250.	9250.	19400.
	OUTFLOW	0.	0.	45000.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	51.92	0.00	7875.	4167.	0.00	63.00	0.00
.50	54.56	0.00	10250.	9112.	0.00	61.00	0.00
.75	56.51	0.00	12142.	14370.	0.00	60.00	0.00
1.00	58.00	0.00	13697.	19766.	0.00	59.00	0.00

PLAN 1 STATION 7

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.25	4167.	47.5	63.00
.50	9112.	53.6	61.00
.75	14370.	58.3	60.00
1.00	19766.	62.1	59.00

PLAN 1 STATION 8

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.25	4163.	42.4	63.00
.50	9103.	45.9	62.00
.75	14361.	48.5	60.00
1.00	19758.	50.6	59.00

PLAN 1 STATION 9

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.25	4159.	35.9	64.00
.50	9098.	39.3	62.00
.75	14339.	41.8	61.00
1.00	19726.	43.9	60.00

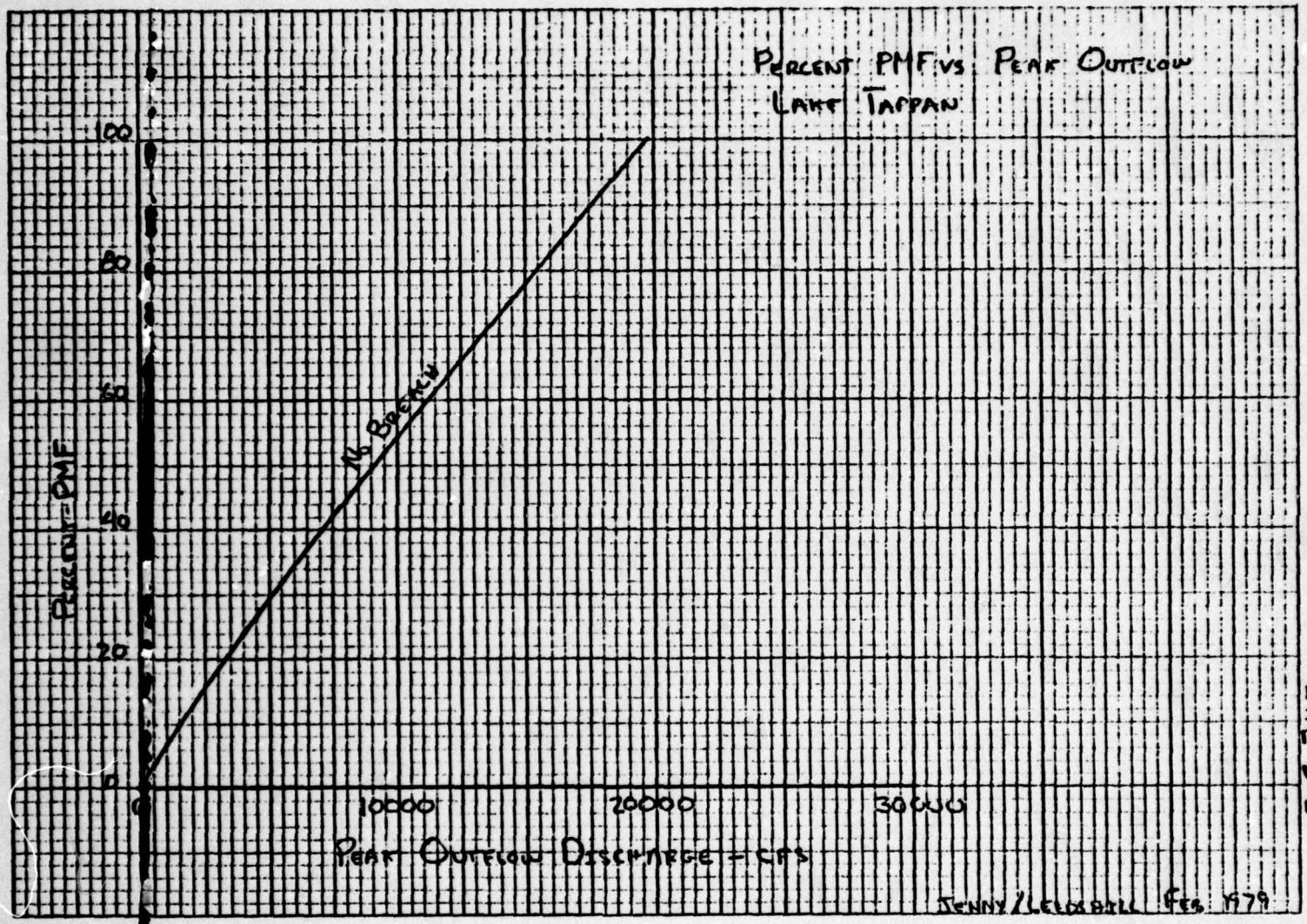
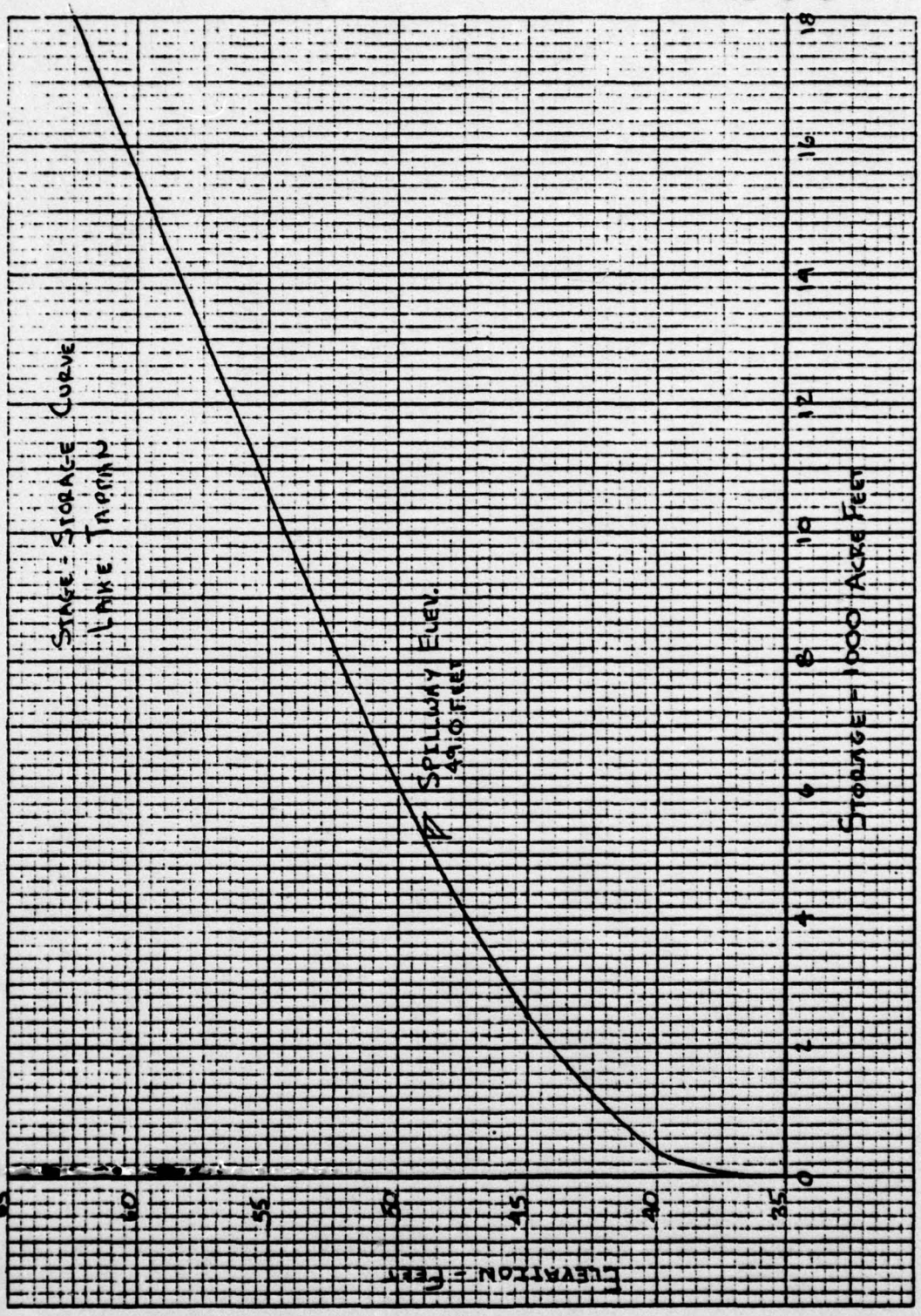

PERCENT PMF VS PEAK OUTFLOW
LAKE TAPPAN
100
80
60
40
20
0
PERCENT PMF
NO BREACH
10000
20000
30000
PEAK OUTFLOW DISCHARGE - CFS
JENNY / LEEDS HILL FEB. 1979

PLATE D-2

PLATE D-3


STAGE - STORAGE CURVE
LAKE TAPPAN
SPILLWAY ELEV.
4910 FEET
ELEVATION - FEET
STORAGE - 1000 ACRE FEET
65
60
55
50
45
40
35
0
2
4
6
8
10
12
14
16
18

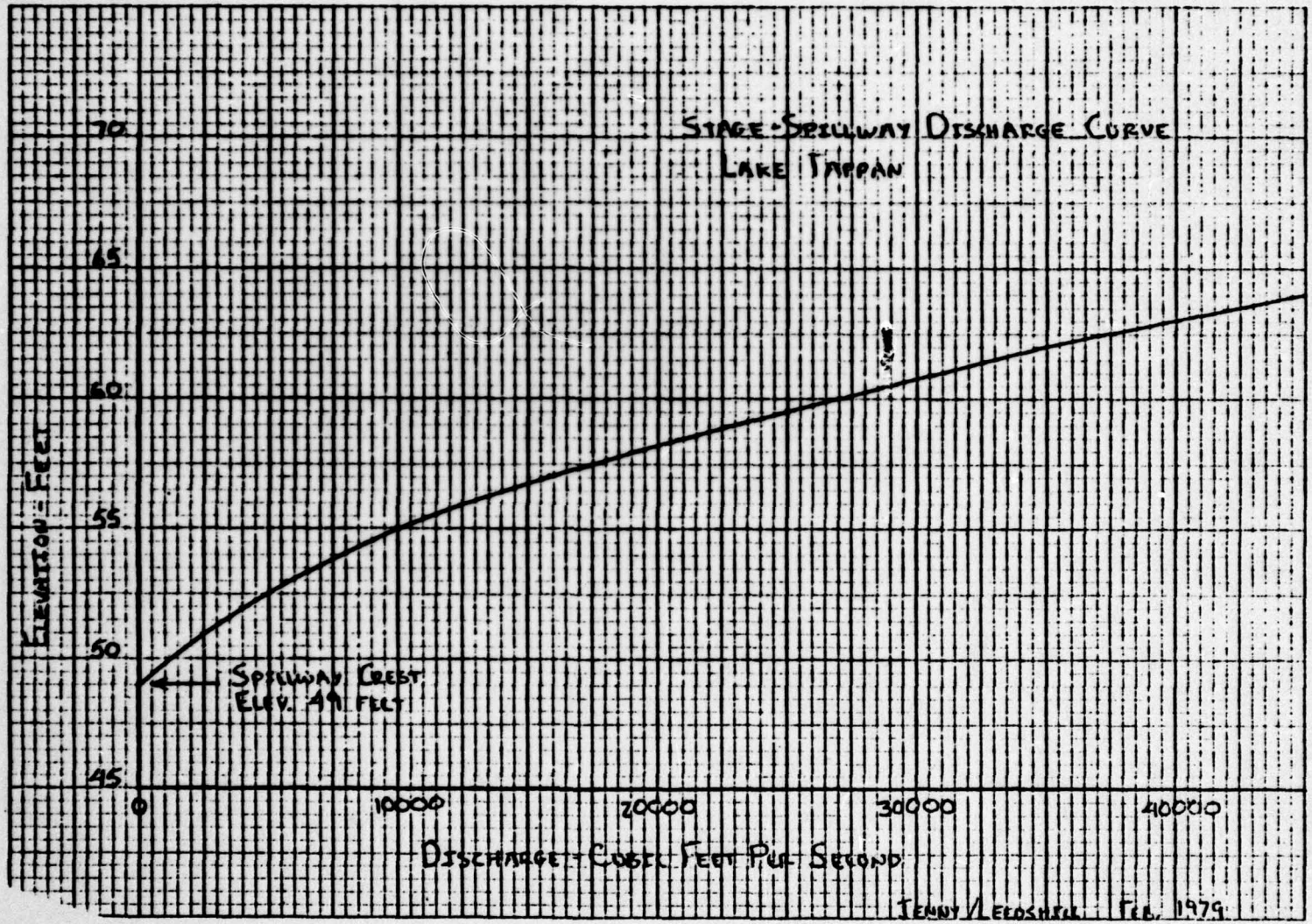

STAGE-SPILLWAY DISCHARGE CURVE
LAKE TAPPAN
ELEVATION - FEET
70
65
60
55
50
45
SPILLWAY CREST
ELEV. 49 FEET
0
10000
20000
30000
40000
DISCHARGE - CUBIC FEET PER SECOND
JENNY/LEEDSHILL FEB. 1979

PLATE D-4